PRESERVATIVES IN FOOD

AND

FOOD EXAMINATION

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BY

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PREFACE

THE extraordinary increase, during recent years, in the use of preserved foods of various kinds, and especially of foods preserved by the addition of antiseptics, has had far-reaching economic results, and the frequent objections made by Public Analysts to the use of antiseptics for this purpose have not only resulted in much litigation, but have threatened seriously to interfere with the development of industries whereby foods, produced in countries where there are not sufficient populations to consume them, have been transferred to other countries where the populations require more than they are able themselves to produce. There have not been wanting also members of the medical profession who, basing their opinions upon theoretical considerations, or upon experience of a very limited number of cases in which the use of such foods had apparently been followed by evil effects, have strongly objected to the use of antiseptics or preservatives. The result has been a desire on the part of the importers and preparers of such foods, and of the general public, for an inquiry into the whole subject, in order that, if possible, the truth might be ascertained. For this reason a Departmental Committee was appointed in 1899 by the President of the Local Government Board to inquire into the use of preservatives (and colouring matters) in the preservation (and colouring) of food, and to report:

1. Whether the use of such materials, or any of them, in

certain quantities is injurious to health, and, if so, in what proportion does their use become injurious?

2. To what extent, and in what amounts, are they used at the present time?

The Committee examined thirty-seven witnesses representing trading companies and societies, and forty-one chemists, medical men, and professional experts, and in 1901 a Report was issued containing all the evidence, and the conclusions arrived at by the members of the Committee as the result of their deliberations. The recommendations made by the Committee will be referred to elsewhere, but they arrived at the very important conclusion that 'the instances of actual harm which were alleged to have occurred from the consumption of articles of food and drink chemically preserved were few in number, and were not all supported by conclusive evidence.' The inquiry showed that practically every person in the United Kingdom who has passed the suckling stage consumes daily more or less food containing chemical preservatives. It is obvious, therefore, that if such food were markedly deleterious some conclusive evidence should have been forthcoming. A study of our mortality records, however, shows that, during the period which has elapsed since such food began to be used, the death-rate as a whole has steadily declined, and it is very probable that one of the causes of this decline is the better feeding of the people in consequence of the introduction of cheaper foods, this being rendered possible by the use of chemical and other means of preservation.

A careful study of all that has been written on this subject both at home and abroad, and of inquiries made of medical practitioners, leads one to the conclusion that the dangers arising from the use of preservatives have been greatly exaggerated. It is impossible to say definitely that a single case of

illness has ever been conclusively traced to the preservative used in any article of food or drink. Preservatives have been used from time immemorial, and it would certainly be strange if with the advance of scientific knowledge better preservatives could not be discovered than those which were originally discovered by uncivilized or semi-civilized man; yet the old preservatives are permitted without question, although some of them are more deleterious if taken in immoderate quantities than their more modern substitutes. Many articles of food contain small quantities of proximate principles of a poisonous character, yet no outcry is ever raised for parliamentary interference with their use; whereas if minute traces of far less potent substances are introduced for the purpose of preventing decomposition, with the consequent formation of decidedly poisonous products, prosecutions at once follow, and attempts are made to show that the Food and Drugs Act is being infringed. The fact that the use of certain preservatives is prohibited in other countries is often quoted as a proof that in those countries the Government have been satisfied that their use was attended with danger to the health of the community, but when such cases are investigated it is always found that there were political reasons for their prohibition, that 'danger to health' was merely a pretext, and that the evidence adduced thereof was of the most unconvincing character.

The subject, however, is one which bristles with difficulties, and it may be that certain preservatives either from their quality or from their use in excessive quantity have an injurious effect upon health, and that the further increase in the use of preservatives may by their cumulative action deleteriously affect certain organs, or insidiously undermine the constitution. Since the issue of the Departmental Committee's Report investigations have been conducted on scientific

lines, chiefly in America, and the results, which are referred to in the various sections, tend to show that danger may be apprehended from the indiscriminate use of certain preservatives. It may be desirable that there should be some restriction as to their employment, and that in certain cases their use should be forbidden, as, for example, in milk. The reasons for these statements will be found fully set forth in the present volume, in which will be found also a summary of all the facts elicited by the Departmental Committee, and which are scattered through their Report.

The question of the danger, if any, arising from the use of colouring matters is a subject of much less importance, but it has been deemed desirable to include a chapter dealing with it.

The Departmental Committee urged the desirability of the appointment of a Court of Reference, such as had previously been recommended by the Select Committee on Food Products Adulteration (1896), the number of which should not be too large, but include at least a chemist, a bacteriologist, a pharmacologist, a physician, a physiologist, and a representative of the Public Health Service. Failing this, they suggest that some definite obligation should be placed upon the Local Government Board to exercise supervision over the use of preservatives and colouring matters in foods. Unfortunately, as yet, no action has been taken, and in the Police Courts the most diverse decisions are constantly being given, the only right of appeal being to Quarter Sessions. Such a condition is in the highest degree unsatisfactory, both to the public and to those engaged in the preparation or sale of articles of food or drink to which preservatives or colouring matters are usually added.

Closely related with the subject of food preservation is that of unsound food, and during recent years it has become notorious that serious and wide-spread epidemics of illness are

attributable to the use of food which has become infected with organisms capable of producing disease. We refer, amongst others, to the cases of so-called 'ptomaine' poisoning which are so frequently reported, to epidemics of scarlet fever, diphtheria, and other forms of illness due to milk, to outbreaks of typhoid fever due to contaminated shell-fish, water-cress, &c., and to the prevalence of certain forms of tubercular disease, probably due to milk from infected cows.

In other cases, numbers of persons have been seriously injured by the use of food or drink which, during the process of manufacture, had become impregnated by some poison, such, for example, as the epidemic of arsenical poisoning in and around Manchester due to beer.

We are not aware of any work in which this subject of unsound food in its relation to health is so fully dealt with as in the present volume, and we have endeavoured to make the sections relating thereto not only generally interesting, but of practical value to Medical Officers of Health, and others interested in the nation's welfare.

Our thanks are due to Mr. Beck for advice *re* Legal Cases, &c., and to Mr. Pratchett for the drawings from which the various illustrations have been produced.

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PART I

CHAPTER I

PRESERVATION OF FOOD BY THE ACTION OF HIGH OR LOW TEMPERATURES, EXCLUSION OF AIR, ETC.

THE changes which a food undergoes when it 'goes bad' may be said to be due exclusively to the propagation and multiplication of micro-organisms—moulds, yeasts, and bacteria—and the products, deleterious or otherwise, of such changes are a part of the life-history of the organisms in question.

Speaking generally, these micro-organisms will only grow in the presence of moisture and between certain temperatures. Multiplication rarely takes place below about 10° C. (though bacteria and spores will survive exposure to a temperature of −180° C.), and ceases as a rule above 40° C.

Nearly all bacteria are killed when submitted to a temperature of about 65° C. for a short time, although their spores are not destroyed unless heated to 100° C. or over for a few minutes. A few 'thermophylic' bacteria, chiefly found in soil and water, appear to thrive best between 60° C. and 70° C., but these are not concerned with the changes in food with which we are dealing. To take a concrete instance, it has been found that the Bacillus acidi lactici, one of the most

important organisms concerned with the souring of milk, will not multiply below 10° C., that it begins to produce lactic acid at 15° C., and that this action reaches a maximum between 35° and 40° C., and ceases at 45·5° C.

Hence it is obvious that if a food is heated for a short time to 100° C. (or better to 105°–110° C. under pressure), and afterwards stored in such a manner that no organisms can obtain access, bacteria, pathogenic or otherwise, will be destroyed, and the food will keep indefinitely.

If heated to 65°–70° C. for about twenty minutes, all the bacteria will be killed, and only their spores, if present, will remain. Fermentation and decomposition will therefore be arrested either until fresh bacteria have obtained access and have multiplied, or until the spores have germinated. As all the principal pathogenic organisms, with the exception of those which cause anthrax, tetanus, and possibly epidemic diarrhœa, are non-sporing, they will be destroyed by this process. The tubercle bacillus is somewhat more resistant than most of the non-sporing bacteria, but it has been shown that in the case of milk a temperature of 60° C. for twenty minutes is sufficient to destroy it, if the heating takes place in a closed vessel so that no film is formed on the surface. Otherwise a temperature of 65°–70° C. for twenty minutes is necessary for this purpose.

If, thirdly, the food is kept below 10° C., bacterial multiplication will be held in check until the temperature again rises.

These three processes are known as sterilization, pasteurization, and refrigeration, respectively.

Sterilization is employed chiefly for tinned foods, the tins being hermetically sealed during the process, and it is also applied to milk.

In the case of sound meat adequately sterilized, there are no disadvantages except such as may possibly arise from the solution of the metal, but in that of milk there are several drawbacks.

In the first place, the milk has a 'cooked' taste; in the second, it is generally held to be less digestible, owing to the changes produced by heat on the proteid constituents; and, thirdly, many physicians consider that infants fed exclusively on sterilized milk are liable to a somewhat serious, but comparatively rare, disease known as infantile scurvy, or scurvy rickets. The evidence on which this view is based is not entirely conclusive, and the relationship has been doubted by many eminent members of the medical profession. It will be more fully considered in a later section.

The disease is readily prevented by the addition of suitable articles of diet, and usually is quickly cured by the administration of the requisite antiscorbutic food: nevertheless, the possibility of its occurrence is, unless the relationship be disproved, a sufficient reason for hesitating to recommend indiscriminate sterilization, since other methods of maintaining the milk in a suitable condition are available.

A further drawback lies in the necessity of the distribution of the milk in bottles, which afterwards require collecting and carefully washing. In spite of this difficulty the sterilization of milk is practised largely in Paris and Denmark, and the Aylesbury Dairy Company do a considerable trade in bottled (sterilized) milk. The Walker-Gordon Company supply untreated milk in bottles, and contend that there is an advantage in so doing, as the risk of contamination is reduced.

The compensating advantages are chiefly that, in addition to the keeping qualities of the milk, all germs, pathogenic and otherwise, are destroyed, and that a single daily delivery is sufficient.

Pasteurization, though applied to wines and beer, is chiefly used for milk and cream. It is carried on to a small extent in England, and to a larger extent in Denmark and other Continental countries. If, immediately after the heating process is completed, the milk is rapidly cooled, the 'cooked' flavour is not noticed. Pasteurization is also less likely to render the milk indigestible, or to produce infantile scurvy, than

sterilization, and it will be equally efficient in destroying the pathogenic germs usually conveyed by this fluid.

On the other hand, since any spores present are unaffected, they will in time propagate bacteria at a suitable temperature, and, though the keeping period of the milk is considerably extended, decomposition is not indefinitely postponed.

Refrigeration.—As has already been pointed out, refrigeration is only a temporary means of arresting fermentation, which recommences as soon as the temperature rises above about 10° C.

It is used chiefly in the case of fresh meat, poultry, game, fish, and dairy products, the temperature employed varying according to the time during which storage is necessary.

Thus for meat, imported into England from abroad, the freezing chambers are kept at about 15° to 20° F. The meat is frozen into a hard mass, which may take some days to resume its natural condition when removed from the chamber. It is held by some that the flavour is partially destroyed by this process, but this opinion is not universal. After thawing, the meat appears to become tainted somewhat more rapidly than fresh meat, though possibly this largely depends on the interval which has elapsed between slaughtering and refrigeration. Frozen meat is equally as nutritious and equally as digestible as fresh meat.

Some large cold-storage firms have certain of their chambers maintained at about 20° F., and in these all kinds of flesh are stored for an indefinite period, whilst others are kept at about 44° F., and are used for meat which only requires storage for a week or two.

These low temperatures are attained by the compression and subsequent expansion of ammonia vapour. The cold produced by the expansion is communicated to brine, and thence to air, previously filtered, which is allowed to circulate through the chambers.

An attempt has been made to apply the refrigerating

process to hams imported in a fresh state from America, to be cured in England, but it has not proved to be a financial success.

In the case of butter, Mr. James Riley[1] stated that New Zealand butter, containing no preservative other than a small quantity of salt, would keep for about three weeks after removal from the refrigerating chamber, and Dr. Voelcker's experiences with Australian butter under similar circumstances corroborated this.[2]

In the case of milk such low temperatures, although perhaps desirable, are not essential, since forty-eight hours should be an ample period between the times when the cow is milked and the milk is consumed.

The relationship between the temperature and the multiplication of bacteria in milk has been investigated by Freudenreich and others. Expressing the number of organisms present at the commencement of the experiments as unity, Freudenreich[3] found that the numbers at different intervals and at various temperatures were as follows:

—	3 hours	6 hours	9 hours	24 hours
59° F.	1	2·5	5	163
77° F.	2	18·5	107	62,100
95° F.	4	1,290	3,800	5,370

It will be noticed that at 59° F. (15° C.) little multiplication takes place for nine hours, while at the temperature of a warm summer's day the increase at the end of twenty-four hours is enormous; this is probably largely due to common species of saprophytic bacteria, which grow more readily at this temperature than at one approaching that of the body, since at 95° F. the increase, which is more strongly marked in six and nine hours than that at the lower temperature, is not maintained.

[1] Report of Departmental Committee on the Use of Preservatives in Food.
[2] *Ibid.* [3] Newman's *Bacteriology and the Public Health*, 1904, p. 185.

Another example is furnished by Professor Conn[1] in the subjoined table :

NUMBER OF BACTERIA PER CUBIC CENTIMETRE IN MILK KEPT AT DIFFERENT TEMPERATURES

No. at outset	In 12 hours at 50° F.	In 12 hours at 70° F.	In 50 hours at 50° F.	In 50 hours or at time of curdling at 70° F.
46,000	39,000	249,500	1,500,000	542,000,000
47,000	44,800	360,000	127,500	792,000,000 36 hours
50,000	35,000	800,000	160,000	2,560,000,000 42 hours

Mr. James Long[2] stated that, according to one of the largest provincial dairy companies in England, milk, if cooled to 54° F., will keep for twenty-four hours, and, if first strained and afterwards cooled, for thirty-six to forty hours in the hottest weather.

Dr. Schidrowitz,[3] by estimating the acidity of samples of milk cooled at once to 50° F., and subsequently kept at a temperature not greater than 60° F., found that the milk remained in a satisfactory condition for sixty hours, whilst without such treatment it would not keep for more than half this time. He further found that this process of cooling was more efficacious for the preservation of milk than the addition of 1 in 50,000 formalin, or 1 in 2,000 boric acid to uncooled milk.

The whole subject of milk preservation will be fully dealt with in a separate section, as it is of the greatest practical importance both to the dairy farmer and the general public.

Exclusion of Air.—The enclosure of food substances in hermetically sealed coverings may be adopted subsequently to sterilization, as in the case of tinned meat and fish preparations, fresh and condensed milk, and the like, or it may be employed without such previous treatment—as, for instance, the coating of fresh eggs with sodium silicate or the plunging of lard into boiling water.

Under both circumstances the effects are twofold : evaporation and oxidation are prevented, and micro-organisms are

[1] Newman's *Bacteriology and the Public Health*, 1904, p. 185.

[2] Report of Departmental Committee. [3] *Ibid.*

excluded. Where complete sterilization is combined with the exclusion of air no putrefaction or fermentation can take place, and the food should remain unchanged indefinitely. During the process of sterilization practically all the air present in solution or in the interstices of the food is driven out, so that exclusion of air is complete.

It is unnecessary to mention the different classes of food which are preserved in this manner, since innumerable instances will suggest themselves.

The drawbacks to this method lie chiefly in failure to ensure sterilization, and, in the case of tinned foods, in the solution of the tin or solder by the juices of the food, with the consequent danger (?) of metallic poisoning.

In the first case, putrefaction, when it has occurred to a considerable extent in a tinned food, is recognized by the 'blown' condition of the tin, by the absence of the inrush of air when it is opened, and by the resonant note elicited when the unopened tin is tapped. Such food often gives rise to symptoms of ptomaine poisoning, characterised by vomiting, diarrhœa, cramps, pyrexia, and prostration.

Tin, zinc, and lead have been found in the food thus preserved, but this danger is avoided when glass or earthenware receptacles are used in place of tins.

Instead of entirely excluding the air, meat has been preserved by removing a portion, and destroying the remainder of the oxygen by sodium sulphite (M'Call's process).[1]

Another method (Jones and Trevithick's process) consists in withdrawing the air, and substituting nitrogen and a little sulphur dioxide.[2]

Processes of this character are not extensively employed, since the bacteria must be previously destroyed, and providing this has been done effectually, and the exclusion of air is perfect, the food will keep for an indefinite period, and it matters nothing whether the gases left in the food itself consist of oxygen, nitrogen, or any other innocuous gas.

[1] Notter and Firth, *Theory and Practice of Hygiene*, p. 362. [2] *Ibid.*

During 1901 the Inland Revenue Department of the Dominion of Canada sent schedules to medical practitioners in the various provinces asking for information as to whether any cases of illness, apparently attributable to the use of tinned foods, had occurred in their practices within recent years.

Out of 1,313 schedules sent, 254 affirmative replies were received.

In many cases the illness was attributed to the presence of metallic salts in the food, taken up from the solder or lining of the can. It is exceedingly doubtful, however, whether any preserved food of this character can take up sufficient metal to produce harmful effects, and the illnesses recorded were more probably due to some change which had taken place in the food-stuff with the production of ptomaines or other noxious bodies, either before or after the canning process, or to bacteria or their spores which had survived the process, and which, when introduced into the human alimentary canal, increased and multiplied, and there produced poisonous substances giving rise to nausea, diarrhœa, or febrile and other symptoms.

Canned food which has produced symptoms of poisoning has frequently presented some peculiarity in appearance, odour, or taste, indicating that the food had undergone change.

Drying.—It has already been mentioned that micro-organisms require moisture for their growth. Hence by thoroughly drying a food microbic fermentation is inhibited.

An example in the case of meat is furnished by the 'biltong of the Boers. Many of the proprietary invalid and infant foods are prepared in this way, such as Liebig's food and Horlick's malted milk.

Bread dried by heat forms the 'pain biscuité' of the French army, while vegetables, fruit, and white of egg are likewise preserved by drying. Dried potatoes are either sliced or granulated, and after soaking become very palatable; and the same is also true of dried green vegetables. They are said to be less efficient as antiscorbutics than fresh vegetables, but are valuable for many purposes. Even milk may be dried and

powdered, and if kept dry will remain sweet indefinitely, but whether, when mixed with water, it forms a liquid with the properties of the original milk remains to be proved. This simple method of preserving food has not, as yet, been utilised as fully as it might be with advantage.

Smoking.—Several articles of food are frequently preserved by being exposed to the smoke from smouldering wood or saw-dust. During this process they are partially dried and the material absorbs certain antiseptic substances from the smoke, the ultimate flavour depending upon the extent of the smoking and the nature of the material used to produce the smoke. Creosote is probably one of the active antiseptic agents. It is a very poisonous substance, and doubtless a great outcry would be raised were anyone to attempt to use it for preserving food, but so long as it is introduced into the food in an old-fashioned manner no objections are raised. It is only when someone wishes to improve upon ancient methods that the effect of prejudice and conservatism makes itself felt. It has never been alleged, so far as we are aware, that smoked meat is unwholesome, though its digestibility is almost certainly impaired. Any modern system of preserving which affected the digestibility to a similar degree would be strongly condemned.[1]

Two kinds of smoking are practised, the slow and the rapid methods. In the former, the meat is exposed to the smoke for several days at a temperature of about 25° C.; and in the latter, largely used in the case of fish, smoke at a temperature of 70° to 100° C. is employed for a few hours. The best woods for producing smoke are said to be juniper bushes, beech chips with juniper berries, and tan-bark with mahogany chips. Fir chips are not desirable, as they affect the taste of the meat unfavourably.

Smoke has a powerfully destructive effect on cultures of

[1] Reference is made in Chapter XV. on 'Colouring Matters' to a preparation called 'Smokene,' consisting of borax, salt, creosote, and a red coal-tar dye; by the external use of this, hams and tongues may appear to have been well smoked.

pathogenic organisms, even anthrax spores being destroyed within eighteen hours. Judging from experiments made, however, with artificially infected meat, the process of smoking appears to act less energetically, the smoke penetrating with difficulty through the layer of coagulated albumen formed on the surface of the meat. Consequently if the interior of a portion of meat be infected with pathogenic germs, although these may be held in check by desiccation, it is improbable that they will be destroyed.

CHAPTER II

CHEMICAL PRESERVATIVES

SODIUM CHLORIDE AND POTASSIUM NITRATE. SALT AND SALTPETRE

Salt.—Common salt is probably the oldest preservative in use, and it certainly is the commonest, since it occurs in practically every sample of ham, bacon, other forms of salted meat, salted fish, butter, and cheese in the market. It is frequently employed in conjunction with saltpetre, and less often with boron compounds.

Many of the preparations used for this purpose contain from 90 to 100 per cent. of sodium chloride, others consist of varying proportions of salt and saltpetre, whilst 'Preservitas,' a substance largely employed by the butter trade, contains 47·8 per cent. of boric acid, 8·6 per cent. of saltpetre, and 11·1 per cent. of sodium chloride.[1]

Before the introduction of the boron compounds both ham and butter were very strongly salted, the butter containing even as much as 15 per cent., whilst 6 to 8 per cent. were common proportions. Such large quantities would not now be tolerated, and mild butters usually have less than 2 per cent. of sodium chloride, while some contain none at all. The strongly salted butters keep sweet for a sufficiently long time for trade purposes, but there is no doubt that mild butter, made in the manner usually adopted in the British Isles and the Colonies, would be rancid long before it was consumed, if no more than 2 per cent. of salt were added.

[1] Report of Departmental Committee. (The composition of this and similar substances is not necessarily a constant one, and different samples of 'Preservitas' may give different analytical results.)

Reference will be made to experiments on this point under the heading of 'Boron Compounds,' and it will be sufficient here to say that in one instance it was found that after nine months butter containing even 6 per cent. of salt had become uneatable.

In one of the Cork creameries,[1] however, where the butter is made from pasteurized cream with the aid of a 'starter,' it has been found that 3 per cent. of salt is sufficient to keep the butter from two to three months.

In the case of hams, occasionally the salt pickle is injected, but more usually the meat is kept in a dry mixture of salt or salt and saltpetre for a week to a fortnight, and is then for export purposes packed in boric acid. Formerly such hams were packed in salt, and the process of curing proceeded during the voyage, but even these highly salted hams were liable to become tainted and fly-blown.[2]

Sodium chloride differs from all the other principal chemical preservatives not only in being an absolutely essential article of diet, but also in occurring in considerable quantities in the human body, more especially in the fluid tissues. It is readily excreted by the kidneys.

Deprivation of salt by use of a diet from which it is normally absent leads to general weakness, anæmia, and œdema, as was evidenced in France before the repeal of the Salt Tax. The acid radicle is required for the formation of the hydrochloric acid, without which peptic digestion would not be efficiently carried on.

In large quantities of a tablespoonful and upwards, salt acts as a mild emetic, and may also purge, indicating that it exerts an irritative effect on the gastro-intestinal mucous membrane.

This is borne out by Liebreich's[3] observations on the action of solutions of sodium chloride on the gastro-intestinal epithelium of a dog, to which reference will be made later.

[1] Report of Departmental Committee. [2] *Ibid.*

[3] *Effects of Borax and Boric Acid on the Human System.*

Distinct signs of inflammation were observed when the salt was present to the extent of 5 per cent.

Scurvy was formerly ascribed to the use of salted foods, but this theory has since been disproved, although the etiology of the disease is still a disputed point.

Braithwaite[1] has suggested a causal relationship between the consumption of salt and the production of malignant disease, but his arguments are not convincing.

Luff has found that sodium chloride hinders the solution of biurate of soda, and hence considers that it is contra-indicated in gout.

Beyond this, however, there is no evidence pointing to the production of deleterious results by the consumption of salt in moderate quantities, and it cannot with our present knowledge be considered a dangerous substance in the proportions used for the preservation of food. It will be observed, however, that it labours under the disadvantage urged so strongly against the use of other preservatives, viz. that in large quantities it produces ill effects, that it is contra-indicated in certain diseased conditions, and that it may render food less amenable to certain of the digestive processes.

Experiments have been made in Amsterdam by Professor J. Forster and Heer de Freytag as to the effect of salting or pickling meat on various forms of bacteria. It was found that cholera bacilli were soon destroyed under the influence of abundance of salt, but that tubercle and typhoid bacilli, staphylococci, the streptococcus of erysipelas, and the bacilli of porcine infectious diseases retained their vitality for weeks or even months. Portions of the viscera of a tuberculous animal, preserved for a considerable time in salt, were found capable of causing tuberculosis in a healthy animal when introduced into the peritoneal cavity. On the other hand, $7\frac{1}{2}$ per cent. of salt destroyed anthrax bacilli in the spleen of an animal in about eighteen hours.

Obviously, therefore, salting has little effect upon many of

[1] *Lancet*, 1901, vol. ii.

the bacteria found in unsound meat. These organisms remain as it were in a dormant condition until such time as they are freed from the influence of the salt, when they may again multiply and increase.

Saltpetre.—As mentioned under the heading of 'Salt,' saltpetre (using this term to include both the potassium and sodium salts) is largely used in salted meats, and to some extent in butter, and reference has been made to the change which has taken place in the quantity of these substances used since the adoption of boron compounds as preservatives.

Pharmacologically there are, however, considerable differences between the chloride and nitrate of sodium and of potassium. Potassium nitrate is liable to produce nausea, vomiting, and diarrhœa, and in large doses tends to inflame the urinary passages, causing hæmaturia; it is also a cardiac depressant, owing chiefly to the basic radicle, since all potassium salts exert this effect to some extent. Small doses are diuretic and diaphoretic, and the drug is occasionally administered for this purpose in doses from 5 to 20 grains. Excretion takes place chiefly through the kidneys.

Liebreich[1] has investigated the effect of saltpetre on some of the digestive ferments. On ptyalin he found that no influence was exerted when the salt was present in the proportion of ½ per cent.

In the case of pepsin 0·5 gramme of the ferment, 0·8 gramme hydrochloric acid, and 0·5 gramme albumen were put into each of several flasks, and varying quantities of saltpetre were added, together with water up to 100 c.c. The flasks were kept at 98·6° F. for twenty-four hours, after which the quantity of albumen digested was estimated. It was found that, when the saltpetre was present to the extent of 0·1 per cent., only three-quarters of the albumen was digested as compared with a control experiment, whilst when it reached a strength of 0·5 per cent. digestion ceased.

[1] *Effects of Borax and Boric Acid on the Human System.*

)sin, saltpetre up to 1 per cent. appeared to be without influence.

The same observer[1] gave 3 grammes of saltpetre daily in addition to ordinary food to a dog weighing 28 kilogrammes. After thirty-six days the dog had lost 5·4 kilogrammes in weight (19·4 per cent.), and had suffered for several days from diarrhœa, to which no doubt the loss of weight was largely due.

Liebreich[2] also investigated the action of saltpetre on the gastro-intestinal epithelium of a dog, and found that a certain amount of inflammation was caused by a ½ per cent. solution, and that this became well marked when the strength reached 2 per cent.

Experimental and clinical evidence therefore indicate that saltpetre has the power of inducing irritation and inflammation of the epithelium of mucous membranes, and cannot be considered an inert substance.

The experiments with pepsin also suggest that meat pickled with saltpetre is more difficult of digestion in the stomach than ordinary meat, although it is a matter of clinical experience that in some cases of flatulent dyspepsia meat thus cured is, if carefully masticated, more readily taken than other forms of flesh.

The question, whether the quantity of saltpetre present in articles of food is sufficient to produce the inflammatory effects referred to, is difficult to answer, since, although the proportions used for curing are known, the quantity absorbed by the meat is not easy to estimate. It is fairly obvious, however, that if long custom had not sanctioned the use of this drug as a preservative, such use would be strongly condemned by those who have the supervision of the purity of our food supplies.

[1] Loc. cit. [2] Loc. cit.

CHAPTER III

CHEMICAL PRESERVATIVES (*continued*)

Boron Compounds

WITH the exception of salt, boron, in the form of borax or boric acid, or a mixture of each, has probably a more extensive application than any other chemical preservative. The presence of one or other of these compounds has been detected in milk, cream, butter, margarine, ham and bacon, fresh meat, salted beef, salted pork, game, poultry, venison, pickled tongue, sausages, pork pies, polonies, minced meat, potted meat, meat extracts, fresh and smoked fish, potted fish, shell-fish, caviare, eggs, lime-juice, lemon squash, wines, ales, fruit juices, vinegar, condensed milk, rennet, and cakes for feeding cattle.[1]

As a rule mixtures of the two substances in a solid or liquid form are sold for use under various trade names, though occasionally one or other is employed in a pure state; sometimes salicylic acid is added. Thus 'Sal Preservare' has been found to consist of 42·6 per cent. of anhydrous boric acid mixed with 15·15 per cent. of borax; 'Preservitas' of 36·5 per cent. of the former and 26·8 per cent. of the latter. 'Arcticanus' and 'Conservare' on analysis have yielded 85·5 per cent. of boric acid, the remainder being borax. 'Burton's Household Milk and Food Preservative' appears to consist solely of boric acid, whilst 'Health Guard' has been found to contain boric acid combined with soda and salicylic acid.[2]

Borax and boric acid both possess very feeble germicidal powers. A saturated solution of the latter in water contains less than 4 per cent. of the salt, and has no effect on the

[1] Report of Departmental Committee. [2] *Ibid.*

spores of the Bacillus anthracis, and is unable to kill pus cocci after five hours' exposure, but Koch found that anthrax bacilli cease to multiply in a medium containing 0·12 per cent. (about 10·5 grains per pint).

Borax is effective in about the same proportions.

Both of these compounds nevertheless appear to have the power of inhibiting the organisms which cause the souring of milk in even more dilute solutions.

Several observers have made experiments in this direction, and their results are on the whole concordant.

Rideal and Foulerton [1] found that milk curdled on being heated to 100° C. as soon as the acidity expressed as lactic acid reached the proportion of 0·25 per cent., and they took this figure as the point at which the milk might be considered sour and unfit for sale. They found that by adding 35 grains of a commercial mixture of boric acid and borax to a gallon of milk (equivalent to 0·05 per cent.) the souring point was delayed, and milk so treated would remain uncurdled for more than twenty-four hours at 75° F., whilst without such addition souring took place within that period. Apparently this is the smallest quantity which can be relied upon to keep milk sweet for twenty-four hours in warm weather.

Mr. H. Droop Richmond, analyst to the Aylesbury Dairy Company, furnished the Departmental Committee with a similar set of figures, showing the number of hours during which milk will keep sweet at various temperatures with and without boric acid :

Temperature F.	Boric preservative added to milk, per cent.		
	None	0·05 (4·4 grains per pint)	0·10 (8·8 grains per pint)
	Hours	Hours	Hours
60°	50	84	110
70°	34	43	54
80°	22	26	36
90°	15	18	27
100°	9	12	23

[1] *Public Health*, 1899.

The point at which the milk might be considered sour was slightly lower than that taken by Rideal and Foulerton, and was equivalent to an increase of 25 degrees of acidity (i.e. 100 c.c. of milk required 25 c.c. more N/10 soda solution to neutralise it with phenol-phthalein as the indicator than when the milk was quite fresh).

It will thus be seen that with the smaller quantity of preservative there is a gain of thirty-four, nine, and four hours respectively at the temperatures usually met with during the warmer months in England, whilst with twice this quantity the figures are sixty, twenty, and fourteen hours respectively. When the temperature is 80° F. the advantage gained by the use of 4·4 grains of preservative per pint is almost negligible.

It is, however, open to doubt whether in these experiments the souring of milk can be taken as a true index of the various fermentative changes actually taking place. Many chemical reagents have, to some extent, a selective action as regards the inhibition of the growth of bacteria. Bacillus coli and Bacillus typhosus will, for instance, grow readily as a rule in broth containing 0·05 per cent. of phenol, whilst most other bacteria are inhibited, and it is not therefore safe to take for granted that boric acid and borax act alike on all the organisms present in milk. Moreover, lactic acid is a product of carbohydrate fermentation, and is therefore unreliable as a criterion of any proteid decomposition that may be taking place simultaneously, and it is worth bearing in mind that it is by the latter kind of change that ptomaines and other poisonous bodies, which appear to be the causal agents in cases of food poisoning, are formed.

Dr. Blaxall,[1] after a series of experiments, came to the conclusion that boric acid inhibited first the organisms producing lactic acid, then those giving rise to butyric acid, whilst certain vegetable moulds proved most resistant.

Delépine[2] has shown that one of the most important group of bacteria having a causal relationship to summer diarrhœa is

[1] Report of Departmental Committee. [2] *Trans. Epidem. Soc.* vol. xxii.

the Bacillus enteritidis (Gärtner). This bacillus flourishes in milk, producing neither permanent acidity, curdling, nor distinct smell, thus indicating that the usual criteria for distinguishing stale from fresh milk are practically useless. Delépine also finds that B. typhosus, B. coli communis, and B. enteritidis continue to multiply in milk at summer's temperature in the presence of as much as 140 grains per gallon of the usual borax and boric acid mixture.

Similar experiments have been made by different observers as to the influence of boric acid on the keeping properties of butter.[1]

One series was conducted by an association of butter merchants in Limerick. A large churning of about 112 lbs. of butter was made and divided into four equal parts. No. 1 was cured with 1 per cent. of preservative; No. 2 with 1 per cent. of preservative and 3 per cent. of salt; No. 3 with 3 per cent. of salt; No. 4 with 6 per cent. of salt. These were stored in similar boxes for nine months. At the end of this period, Nos. 1 and 2 were good and eatable, while Nos. 3 and 4 were uneatable and rancid.

Mr. H. C. Cameron, Produce Commissioner to the New Zealand Government, related to the Departmental Committee experiments made by his Government. Six samples of butter, marked A, B, C, D, E, and F, from the same churning were treated with different quantities of salt and preservative (chiefly consisting of boric acid). These were examined and found to be practically identical in flavour, and were then kept at a temperature of 29° F. in a freezing chamber for eleven weeks, as representing the period necessary for transporting to England. They were then taken out and kept for ten days at a temperature varying from 45° to 60° F., corresponding to the period of storage in the English shops, and were re-examined by experts. As a result, it was found that box E, in which the butter had received 3 per cent. of salt and ½ per cent. of preservative, was superior to sample D, which was

[1] Report of Departmental Committee.

treated with 2 per cent. of salt and 1 per cent. of preservative, and this was superior to F, which had received 3 per cent. of salt and 1 per cent. of preservative, whilst A, B, and C, which had no preservative of any kind, were all inferior to D, E, and F. They concluded, therefore, that the best results were obtained with ½ per cent. of preservative, though it is not quite obvious why E and F should be of inferior quality, unless the extra amount of preservative was perceptible to the palates of the observers.

On the other hand, Dr. Voelcker stated in his evidence that he had received from Australia samples of butter, some of which contained preservative and some of which were without; these were kept side by side in his laboratory, and at the end of six weeks he was unable to detect any difference between them, although the observations took place during the summer. It is, however, possible that a butter expert would have been able to discern a difference.

Discordant results such as these can be readily understood when the biological changes taking place in the manufacture of butter are borne in mind. If butter is made from pasteurized cream by means of a pure 'starter,' such germs as cause rancidity and other deleterious changes may not have an opportunity of gaining access, and the addition of boric acid or borax may therefore not have any marked effect on the flavour; whilst if these organisms are not removed at the factory or creamery, they will indicate their presence unless checked by means of a preservative.

In any case ½ per cent. is considered sufficient by a large number of those connected with the butter trade, and when containing this proportion well-made butter will keep a sufficient time to be imported into England and sold for consumption.

A similar quantity of boric acid is, according to Mr. Hudson (of Hudson Bros.), sufficient to keep cream sweet until it comes into consumption.[1]

[1] Report of Departmental Committee.

In the case of ham and bacon boron preservatives are usually applied to the outside of the joint or side, the quantity used by different wholesale dealers for this purpose varying from $\frac{1}{4}$ to 1 per cent. A certain proportion of this appears to be absorbed, and is found in the interior of the meat.

Boric acid is frequently used medicinally, both internally for disinfecting the urinary tract and for relieving flatulence, and externally as an application for inflammatory conditions, and for washing out suppurating cavities, &c. The dose, which was formerly 5 to 30 grains, was diminished in the 1898 edition of the British Pharmacopœia to 5 to 15 grains, the smaller giving as good results as the larger.

Borax is often used as an application in cases of thrush and similar conditions of the mouth, and was formerly largely given internally for epilepsy. Like that of boric acid, the maximum dose has been halved, and is now 20 grains.

Both these substances are as a rule quickly eliminated by the kidneys. When given in small doses boric acid is excreted as a borate, but with larger doses it appears unchanged, indicating that the alkaline pancreatic juices have been unable to neutralize the acid. It has been found in the urine within four hours of the initial dose, and it generally disappears within forty to forty-eight hours after the drug has ceased to be administered.

When, however, the kidneys are diseased the elimination is less rapid, and two instances were mentioned in the Report of the Departmental Committee in which boric acid was found in the urine forty-nine and fifty-three days respectively after the drug was left off. It is probable, therefore, that occasionally boric acid may have a cumulative action.

Many experiments have been performed *in vitro* with a view to ascertaining what action, if any, boron compounds exert on the various digestive juices.

For those who are unacquainted with physiological processes it may be briefly stated that digestion is carried out by the action of ferments secreted by special glands. The ferments

split up the starchy and nitrogenous constituents of food into sugars and proteid bodies, capable of being absorbed into the blood and utilised by the body.

In the mouth the food is masticated with saliva containing the ferment ptyalin, which splits up starch into dextrin and sugar. When the food passes into the stomach this process probably proceeds for a further period until checked by the hydrochloric acid secreted by the stomach. The latter organ also produces pepsin and rennin: the former, in the presence of hydrochloric acid, acting on the nitrogenous portion of the food, whilst the rennin precipitates casein from milk, and so allows the pepsin to convert it into proteid bodies capable of being absorbed by the intestine.

The pancreas secretes two ferments, trypsin and amylopsin, which act respectively on nitrogenous and carbohydrate material, and so deal with any food which may have escaped the action of the ptyalin and pepsin.

The functions of the intestines are chiefly concerned with the absorption of food prepared in the manner indicated, though a ferment, succus entericus, is also produced which appears to have some action on carbohydrate food.

Fats undergo a slight chemical change as a rule, and are then absorbed in the form of an emulsion. The emulsifying effects are chiefly produced by the pancreatic juice and bile.

When studying the effects of boron compounds on the various ferments, it must be borne in mind that whilst boric acid possesses very feeble acid properties, borax is distinctly alkaline, as the differences found in the action of these substances are probably largely due to their respective reactions.

Salivary Digestion.—Chittenden[1] obtained mixed human saliva, filtered and neutralized it, and diluted it to one-half. His experiments were made in series, in which one digestion of each series served as a control for comparison. Ten c.c. of the diluted saliva was mixed with 1 gramme of perfectly

[1] *Dietetic and Hygienic Gazette*, February 1893.

neutral potato or arrowroot starch, the volume made up to 100 c.c. with water, and various percentages of boric acid or borax added. The mixtures were kept at 40° C. for fifty minutes, after which further fermentative action was stopped by boiling the solutions. The extent of the amylolytic—change of starch into sugar—action was ascertained by determining the amount of maltose formed in one-fourth of the solution.

In the case of saliva acting on potato and arrowroot starch in the presence of borax, the following results were obtained:

Borax added	Maltose formed	
	Potato starch	Arrowroot starch
0·00 per cent.	70·40 per cent.	67·08 per cent.
0·005 "	—	65·68 "
0·01 "	65·96 "	62·48 "
0·05 "	49·44 "	39·16 "
0·10 "	41·84 "	36·84 "
0·50 "	40·56 "	30·60 "
1·00 "	37·60 "	27·20 "
2·50 "	29·36 "	22·36 "
5·00 "	22·68 "	17·32 "
10·00 "	17·56 "	13·28 "

From this it will be gathered that borax exerts an inhibitory effect on ptyalin, but is unable to arrest its action even when present in the large proportion of 10 per cent.

Boric acid appears to have still less effect in this direction, as shown by the following figures, the amylaceous material being arrowroot starch:

Boric acid added	Maltose formed
0·0 per cent.	67·08 per cent.
0·05 "	67·72 "
0·10 "	67·76 "
0·50 "	68·08 "
1·00 "	62·76 "

It will be seen that the addition of boric acid up to a certain point actually appears to increase the quantity of

starch converted into sugar. It was further found that this change was not prevented by an addition of salt up to 5 per cent.

Liebreich[1] obtained similar results with borax, using 10 c.c. of mixed human saliva with 20 c.c. of a 2½ per cent. decoction of starch, the whole being made up to 100 c.c. Two portions contained 0·1 and 0·5 per cent. of borax respectively, whilst a third was used as a control. The mixtures were kept at 50° C. for an hour and then boiled, and the sugar estimated. His results were as follows:

Borax added	Sugar formed	Loss from addition of borax
0·0 per cent.	0·2075	—
0·1 "	0·164	20·96 per cent.
0·5 "	0·158	23·85 "

Similar experiments were performed, leaving the ferment in contact with the starch for twenty-four hours:

Borax added	Sugar formed	Loss from addition of borax
0·0 per cent.	0·249	—
0·1 "	0·204	18·07 per cent.
0·5 "	0·205	18·07 "

These results have been further confirmed in England by Rideal and Foulerton and others, and tend to show that whilst boric acid rather favours the amylolytic action of saliva, borax and mixtures containing both substances retard it. It should, however, be remembered that starchy foods such as bread, for which this action is chiefly required, are not usually preserved, though, in the case of bread and butter and milk puddings, the addition of borax might retard this preliminary digestion by the salivary ferments.

Pepsin Digestion.—Peptic digestion takes place in an acid medium, and for this purpose hydrochloric acid is secreted by special cells in the stomach wall. This acidity at the height of

[1] *Effects of Borax and Boric Acid on the Human System.*

digestion is equivalent to about 0·2 per cent. of hydrochloric acid. At the commencement of gastric digestion no free hydrochloric acid is present, as it forms a compound (hydro-chlor-protein) with the proteid material of the food. When the proteids are fully saturated, free hydrochloric acid appears. To a certain extent the flow of gastric juice is excited by the introduction of an alkali, and borax may therefore exert this effect, and also neutralize the lactic acid, which is an abnormal product and due to microbic fermentation of the food in the stomach. On the other hand, an excess of alkali may have a prejudicial effect in tending to neutralize the hydrochloric acid essential for the process of proteid digestion.

Chittenden[1] investigated the action of boron preservatives on pepsin by digesting coagulated egg albumin for a given time with varying quantities of borax and boric acid, using, as a control, mixtures in which there were no preservatives.

Each mixture consisted of 9 grammes of albumin (containing 1·247 grammes of dry proteid) and 100 c.c. of pepsin hydrochloric acid, prepared by dissolving 0·1 gramme of a very strong pepsin in 1 to 2 litres of a 0·2 per cent. solution of hydrochloric acid. The amount of albuminous matter dissolved after standing for four hours at 40° C. was taken as a measure of the proteolytic action under the given conditions. The results were as follows:

Borax added	Boric acid added	Proteid digested
0·00 per cent.	0·00 per cent.	73·2 per cent.
0·01 "	—	73·3 "
0·05 "	—	75·3 "
0·20 "	—	71·8 "
0·50 "	—	57·1 "
	0·10 "	74·5 "
	0·30 "	82·3 "
	0·50 "	81·2 "
	1·00 "	82·6 "
	2·50 "	73·6 "
	5·00 "	46·1 "
	6·00 "	41·3 "

[1] *Loc. cit.*

In a second series of experiments a weaker digestive mixture was used in the presence of boric acid, while the proteid employed was 1 gramme of blood fibrin in each solution. Digestion went on at 40° C. for six hours, the results being as under:

Boric acid added	Proteid digested
0·00 per cent.	36·2 per cent.
0·05 ,,	36·0 ,,
0·10 ,,	38·5 ,,
0·50 ,,	38·0 ,,
1·00 ,,	34·9 ,,
5·00 ,,	28·4 ,,

These experiments seem to show that *in vitro* any effect which boric acid, in quantities up to about 1 per cent., may have on peptic digestion is rather in the direction of accelerating than retarding the action. Borax, on the other hand, appears to inhibit the process when the percentage rises to 0·2 per cent., possibly on account of its neutralizing effect on the hydrochloric acid. If this be the cause, it would probably be overcome in the stomach by the continued secretion of acid from the oxyntic cells.

Chittenden's results were to a certain extent confirmed by Liebreich,[1] who, however, used somewhat different methods. He mixed 0·5 gramme pepsin, 0·8 gramme hydrochloric acid, and 0·5 gramme albumin with varying quantities of borax (neutralized by N/10 hydrochloric acid) and boric acid; 100 c.c. of water was added, and the flasks left for twenty-four hours at 35° C.

In the case of borax he found that with quantities up to 0·25 per cent. all the proteid was dissolved, whilst a small residuum was left when the strength reached 0·5 per cent. In the case of boric acid all the proteid was digested even when 0·5 per cent. of the acid was added. These experiments are open to the objection that a contact of twenty-four hours was allowed, which is a longer period than would obtain naturally.

[1] *Effects of Borax and Boric Acid on the Human System.*

Action on Rennin.—Any effects produced by boron preservatives on rennin are of particular importance, since for the proper digestion of milk, on which infants and invalids so largely depend, it is essential that this ferment action shall take place before proteolytic action commences. Halliburton [1] has found that whilst boric acid has no effect on rennin, minute proportions of borax, even 0·1 per cent., are sufficient entirely to arrest the curdling action for twenty-four hours at least. If, therefore, the acid present in the gastric juice is unable to convert the borax into boric acid, the digestion of milk to which the above quantity of borax may be added will probably be arrested.

Action on Amylopsin.—This ferment acts normally in an alkaline medium, though digestion will also take place in a neutral solution.

Liebreich[2] found by experiments *in vitro* that 3 per cent. of boric acid did not inhibit the action of amylopsin, whilst borax had a slight effect in this direction. He obtained a solution of the ferment from the gland of a pig, mixed it with a decoction of starch, and allowed the mixture to stand for twenty-four hours at 35° C. The albuminoid bodies were separated, and the quantity of sugar estimated. His figures were as follows:

Borax added	Boric acid added	Quantity of glucose formed
0·00 per cent.	0·00 per cent.	0·791 gramme
0·66 "	—	0·768 "
1·33 "	—	0·770 "
1·99 "	—	0·753 "
	1·66 "	0·790 "
	3·33 "	0·789 "

These experiments are open to the objection that they fail to show the presence or absence of any inhibitory effect which may be exerted during such period of time as the food is exposed to the action of the pancreatic ferments in the human body.

[1] Report of Departmental Committee. [2] *Loc. cit.*

Foulerton,[1] in quoting experiments made by Rideal and himself, states that, taking the value of the digestive power of amylopsin on arrowroot starch as 100, by the addition of various quantities of a mixture (consisting of 75 per cent. boric acid and 25 per cent. borax), the process of digestion in thirty minutes was retarded as follows:

Boric mixture added	Quantity of sugar formed	
	Weak amylopsin	Strong amylopsin
0·00 per cent.	100·0	100·0
0·05 „	77·2	64·0
0·1 „	63·0	53·6
0·3 „	50·8	47·0

It will be seen that these figures differ considerably from those of Liebreich, the explanation being probably in the great difference of time allowed by the two observers. If Rideal and Foulerton had estimated the sugar formed at the end of twenty-four hours, they would very likely have found that the additions had made little difference to the amount of starch converted into sugar.

Their observations, however, are probably of more value than Liebreich's, since pancreatic digestion cannot be supposed to continue for the length of time allowed in the latter's experiments.

Action on Trypsin.—Like amylopsin this ferment will act in an alkaline or a neutral medium, though in the intestine the former condition is the one which obtains.

Chittenden[2] investigated the influence of borax in both a neutral and an alkaline solution, and that of boric acid in a neutral medium. The albuminous material employed was 10 grammes of cooked beef proteids, which were mixed with 50 c.c. of the neutral trypsin and varying quantities of borax. These mixtures were kept at 40° C. for four hours, with the following results:

[1] *Lancet*, November 1899. [2] *Loc. cit.*

Borax added	Proteid digested
0·00 per cent.	35·8 per cent.
0·01 ,,	43·2 ,,
0·05 ,,	43·7 ,,
0·20 ,,	51·3 ,,
0·50 ,,	56·9 ,,
1·00 ,,	57·2 ,,
2·00 ,,	61·2 ,,
3·00 ,,	59·1 ,,
5·00 ,,	56·1 ,,
10·00 ,,	48·8 ,,

In an alkaline medium (containing 0·5 per cent. of sodium carbonate) similar results were obtained:

Borax added	Proteid digested
0·00 per cent.	57·5 per cent.
0·01 ,,	64·1 ,,
0·05 ,,	65·0 ,,
0·20 ,,	67·4 ,,
0·50 ,,	69·2 ,,
1·00 ,,	63·3 ,,
2·00 ,,	64·5 ,,
3·00 ,,	56·5 ,,
5·00 ,,	52·9 ,,
10·00 ,,	45·7 ,,

When a stronger solution of trypsin was used the accelerating effect of borax was to a large extent lost.

In the case of boric acid a neutral solution of trypsin was used, the mixture being allowed to stand for seven hours before the amount of digested proteid was estimated:

Boric acid added	Proteid digested
0·00 per cent.	25·9 per cent.
0·01 ,,	25·3 ,,
0·02 ,,	24·9 ,,
0·05 ,,	24·1 ,,
0·10 ,,	23·7 ,,
0·20 ,,	24·4 ,,
0·50 ,,	24·3 ,,
1·00 ,,	24·3 ,,
2·00 ,,	19·8 ,,
3·00 ,,	18·9 ,,

It will be noticed from these experiments that whilst boric acid appears to exert on the whole a slightly inhibitory action, borax favours the action of trypsin. Similar results were obtained by Foulerton.[1]

Although the ferments thus experimented on cover the most important of those met with in digestion, the action of boron preservatives on the emulsifying properties of the bile and pancreatic juice have not been directly determined. It might be supposed that borax would favour and boric acid hinder this process, though the investigations, to be quoted later, on the results of administering borax and boric acid to children and animals would seem to show that no appreciable influence is exerted.

To sum up, although too much stress must not be laid on experiments conducted *in vitro*, borax in small quantities appears to exert a markedly prejudicial effect on the action of rennin and a slighter one on ptyalin; when present in a greater proportion than 0·2 per cent. it also retards peptic digestion. Unless added in large quantities it rather favours than retards the action of trypsin.

Boric acid, on the other hand, has no action on rennin, slightly retards the action of ptyalin when present in the proportion of 1 per cent., favours peptic digestion until of a greater strength than 1 per cent., but begins to retard the action of trypsin when present to the extent of 2 per cent. Of the two substances, therefore, boric acid is less likely, judging from these experiments, to exert a prejudicial effect on digestion than borax.

As regards amylopsin, which is a most important ferment from a physiological point of view, there can be no question that small quantities of boric mixture retard the action, though after a considerable lapse of time the quantity of starch converted into sugar is almost the same whether the preservative is present or absent.

Foulerton and Rideal[2] also estimated the digestibility of

[1] *Lancet*, November 1899. [2] *Loc. cit.*

meat and milk which had been in contact with a mixture of boric acid and borax. Fifteen grammes of beefsteak was allowed to stand for twenty-four hours in 100 c.c. of water containing the mixture (boric acid 75 per cent., borax 25 per cent.). The meat was then digested for an hour at 38° C. with pepsin. The dissolved nitrogen in the filtrate was then estimated, with the following results:

Control (containing no preservative)	Boric mixture		
	0·05 per cent.	0·1 per cent.	0·3 per cent.
100·0	97·22	90·17	73·93

In the case of milk 50 c.c. was allowed to stand in contact with the preservative for twenty-four hours, after which the mixture was digested with commercial extract of pancreas for half an hour at 38° C. The undigested casein was precipitated and the dissolved nitrogen in the filtrate estimated:

Control (containing no preservative)	Boric mixture		
	0·05 per cent.	0·1 per cent.	0·3 per cent.
100·0	99·4	97·3	97·7

It would therefore appear that, whilst the digestibility of meat may suffer when exposed to boric acid of a greater strength than 1 in 1,000, there is little effect in the case of milk. Similar experiments in which rennin and pepsin were used might give different results.

Liebreich [1] has made a number of experiments with regard to the direct effect of boric acid and borax on gastro-intestinal epithelium. Under narcosis the stomach and intestine of several dogs were laid open and irrigated for five minutes with ½, 1, 2, 3, and 5 per cent. solutions of boric acid and borax respectively. For purposes of comparison similar experiments were made with solutions of common salt, saltpetre, and soda. The mucous membrane of the stomach and intestine was

[1] *Arch. of Hygiene.*

examined while fresh, by the naked eye and microscopically, and permanent microscopic specimens were afterwards made.

He found that boric acid even in a 5 per cent. solution exerts no irritating effect on the gastro-intestinal mucous membrane. Borax, on the other hand, began to cause excess of secretion and disintegration of the epithelial lining when a strength of 2 per cent. was reached. At 1 per cent. there were very slight changes visible under the microscope. He ascribes this to the alkaline reaction of the drug. With a 1 per cent. solution of soda he found a distinctly deleterious effect, though the comparison is perhaps hardly fair, as he should have compared equal degrees of alkalinity of borax and soda rather than equal weights.

Experimenting with saltpetre he found that the injurious effect began with a ½ per cent. solution, whilst a 5 per cent. solution of common salt exercised an inflammatory action on the gastro-intestinal mucous membrane. He concluded that boric acid is less injurious to mucous membranes than common salt or saltpetre, while the latter is capable of producing inflammation in weaker solutions than borax.

The effects of the administration of boron compounds on the nutrition of animals have been investigated by Chittenden, Liebreich, Rideal and Foulerton, Tunnicliffe and Rosenheim, Annett, and others.

Chittenden[1] used dogs for the purpose of his experiments, bringing them first into a condition of nitrogenous equilibrium. They were then fed on a carefully weighed mixed diet of meat, fat, and carbohydrate for nine days. Each dog at the commencement of the experiments weighed 12 kilogrammes. For the next nine days 5 grammes of borax (about 77 grains) was administered daily in the same quantity of food, an amount equivalent to 1·3 per cent. of the solid food and 0·6 per cent. of the total food and drink. For a further period of nine days the borax was omitted. The nitrogen of the urine and fæces was determined daily, also the volume of the urine, together

[1] *New York Medical Journal*, February 26, 1898.

with its specific gravity, total sulphur and phosphorus, uric acid and combined sulphuric acid, &c. The fatty or ether-soluble matter of the fæces was also determined.

Similar observations were made with boric acid, the experiments extending over thirty days equally divided into a fore, a boric acid, and an after period. From 1 to 2 grammes (15·5 to 31 grains) of the salt was given per diem.

A third series of experiments was made, lasting over fifty-six days. During the first eight days no preservative was given. An average quantity of 4 grammes of borax was administered per diem during the next eight days; there was then a further period of eight days during which no borax was administered, after which boric acid was given for a like period, the total average quantity per diem being $2\frac{1}{8}$ grammes. Another rest of eight days was allowed, after which an average quantity of 8 grammes of borax was given daily for eight days, and finally this was followed by an equal period during which no antiseptic was administered.

The experiments showed, in the case of borax, administered up to a maximum dose of 5 grammes a day, that while the weight of the animal remained constant, and the quantity of fat in the fæces was not increased, there was a slight rise in the quantity of nitrogen excreted in the fæces, which might indicate that less proteid is absorbed when borax is administered. The urine showed a tendency to become alkaline and to decrease slightly in quantity.

Boric acid in doses up to 3 grammes a day was apparently without influence on proteid metabolism or on the general nutritional processes of the body. It also had no effect on the volume of the urine, which remained acid.

Both these drugs, however, when administered to the extent of 1·5 to 2·0 per cent. of the food were liable to produce nausea and vomiting. No cumulative action was observed, elimination being completed in twenty-four to thirty-six hours.

Liebreich[1] fed two dogs, weighing 12,700 and 8,530 grammes,

[1] *Loc. cit.*

on food containing 3 and 2 grammes of boric acid respectively per diem. Vomiting occurred on the twelfth and fifteenth days in the two cases, but the first dog in thirty-six days put on 260 grammes in weight. The weight of the second underwent no change.

Three rabbits, varying from 1,170 to 1,370 grammes respectively, were given 0·3 gramme of boric acid for thirty-one days, and gained from 30 to 100 grammes in that time.

A dog weighing 12,200 grammes had 5 grammes (77 grains) of borax administered daily in its food for ninety days. On the sixteenth day there were symptoms of acute intestinal inflammation, but these passed away in a few days, and at the end of the period the dog had gained 3,400 grammes.

The results of these experiments showed that in the case of borax there was no loss of weight, a slight increase in the quantity of fæcal nitrogen, but no change in the ether-soluble constituents of the fæces, from which it was inferred that proteid and fat assimilation are practically not affected by doses of borax up to 5 grammes a day. The urine showed a tendency to become alkaline, together with a slight decrease in quantity.

Boric acid in doses up to 3 grammes a day was likewise without influence on proteid and fat metabolism or on the general nutritional processes of the body. It also appeared to be without effect on the volume of urine, which remained acid.

Neither drug had any influence on intestinal putrefaction.

In order to ascertain the effects of boric acid on young animals a number of observations were made at the South-Eastern Agricultural College, Wye, by Messrs Hall, Hammond, and Tunnicliffe, sucking-pigs being used for the purpose.[1] The experiments were very carefully conducted, and controls were used for comparison. Eight pigs of the same breed were matched in pairs as nearly as possible according to their

[1] Report of Departmental Committee.

weights. They were about two months old when the experiments began. They were fed to their maximum capacity on a diet consisting chiefly of meal made from barley, oats, or wheat; each individual of a selected pair received the same quantity of food as the other, but to the food of one the boric preservative was added. Their initial weight ranged from 30 to 40 lbs., and their final weight, after nine weeks, was from 70 to 90 lbs. The daily dose of boric acid began at 3 grains and was gradually increased to 37 grains. During the last twenty days of the experiments the fæces were collected, and the fat and nitrogen estimated in two nine-day periods, the first period being one in which the dose was 18·5 grains, and the latter 37 grains per day.

The results were, within experimental errors, entirely negative—that is to say, the pigs receiving boric acid throve as well as their confrères, and there was no evidence of appreciable diminution in the fat or nitrogen assimilated.

As far, therefore, as experiments on animals can be considered an indication of what would probably obtain in man under similar conditions, these experiments would seem to indicate that moderate doses of boron preservatives are not likely to produce ill-effects even when administered over a considerable period, and the experiments at the Agricultural College go a short distance to show that the same may also be true with regard to the young. It must be borne in mind, however, that the digestive processes taking place in animals are not entirely comparable with those in man. For instance, perchloride of mercury and iodoform can be given to dogs in quantities sufficiently large completely to sterilize the alimentary canal without ill effect, whereas corresponding doses would be fatal to man.[1]

Dr. Annett[2] has experimented on the administration of boric acid dissolved in milk to a number of kittens just old enough to lap milk. These were chosen as more nearly

[1] Halliburton, Report of Departmental Committee.
[2] Report of Departmental Committee.

representing infants in the nature of their food, and presumably their digestive processes, than the animals used by other observers. Some were fed on milk containing 80 grains of boric acid per gallon, and the others on milk containing half this quantity of acid, and the kittens were allowed to consume as much of it as they wished. At the same time control kittens were fed in a similar manner on milk free from preservatives.

At the end of the third or fourth week all the kittens fed on the milk containing 80 grains of boric acid per gallon were dead, having previously undergone great emaciation, whilst those consuming the milk with 40 grains of the preservative per gallon became emaciated and died a little later. In all these cases diarrhœa was a prominent symptom. The control kittens remained perfectly healthy, and gained considerably in weight. Dr. Annett found that kittens three months old were practically insusceptible to milk containing these quantities of boric acid.

Although the actual volume of milk consumed was not estimated, the experiments are extremely suggestive, as showing what might possibly happen to infants artificially brought up on milk to which boric acid has been added. The proportion of 40 grains per gallon is (as shown on p. 17) nearly the minimum quantity which can be relied upon to preserve milk for any appreciable length of time.

Turning now to the observations made on children, Tunnicliffe and Rosenheim[1] obtained the consent of the parents of three children to keep the latter under observation, whilst measured doses of boric acid and borax were administered. Two of them were typically healthy boys, two and a half and five years of age, whilst the third was a girl of four, delicate, and just recovering from pneumonia. During the whole period, lasting a little over three weeks, absolute control was kept over all ingesta, which were accurately weighed, and the excreta, which were daily collected without loss. The habits and exercise of the children were regular in every respect. Each

[1] *Journal of Hygiene*, vol. i. p. 168.

period was divided into a fore, a boric, a borax, and an after period. The diet was a mixed one, consisting chiefly of milk, bread, butter, meat, and fruit, and so selected as to maintain a nitrogenous equilibrium. Each article of food was carefully analysed with regard to its percentage composition. The excreta were measured or weighed, and the nitrogen, phosphorus, uric acid, and fats estimated.

The doses of boric acid and borax were the same in all three cases.

For three days 7·7 grains of boric acid was given per diem, for three days 10·2 grains, and for one day, 15·4 grains. 23·2 grains per day of borax was given for five days. The following are approximately the maximum quantities of the substances which would be given medicinally:

—	Boric acid	Borax
Boy aged 2½ . .	8 grains	13·5 grains
Boy aged 5 . .	13·2 „	17·6 „
Girl aged 4 . .	11·25 „	15·0 „

The fore period lasted eight days in the first case, five days in the second and third. The boric acid and borax periods were in each instance seven and five days respectively, whilst the after period lasted five days in every case.

The conclusions arrived at were as follows:

Boric Acid

'1. Small doses up to 1 gramme (15·4 grains) a day exert in healthy or delicate children no influence upon proteid metabolism. The assimilation of the proteid food was improved in one healthy child.

'2. The phosphorus metabolism was unaffected in all cases. The assimilation of phosphorus was in all cases improved.

'3. The assimilation of fat was not affected.

'4. The body weight increased in all cases.

'5. The quantity of dry fæces was not affected. Their nitrogen percentage was slightly decreased.

'6. No inhibitory effect upon intestinal putrefaction could be demonstrated.'

Borax

'1. Continued doses of 1·5 gramme (23·2 grains) have no influence in healthy or delicate children upon proteid metabolism. The proteid assimilation was unaffected in healthy children, slightly depressed in the delicate child.

'2. The phosphorus metabolism was not affected in healthy or delicate children. 'The assimilation of phosphorus was improved in all cases, the improvement being least marked in the case of the delicate child.

'3. The fat assimilation was improved in the case of one healthy child, and unaffected in the case of the others.

'4. The body weight was increased in all cases; the increase was most marked in the case of the delicate child.

'5. The weight of dry fæces and their nitrogen and phosphorus percentage remained unaltered.

'6. Borax tended rather to increase intestinal putrefaction.'

Boric Acid and Borax

'1. Both boric acid and borax were quickly eliminated, no cumulative action being therefore probable.

'2. Neither boric acid nor borax in any way affected the general health and well-being of the children.'

If any criticism is needed upon these admirably conducted observations, we would point out that the period of administration was a somewhat short one, and although apparently no cumulative action took place, a more prolonged administration might possibly have led to some digestive disturbance. Moreover, whilst the children were taking for the greater part of the time an amount of boric acid nearly equivalent to, or in one case exceeding, the maximum dose authorised by the British Pharmacopœia, the quantity of boric acid actually found in milk is, as will be mentioned in a later chapter, frequently

20 grains[1] to the pint, so that an infant of, say, six months, consuming only a pint of milk in the twenty-four hours, might take considerably more boric acid than the quantity used in these observations.

The increase of intestinal putrefaction in the case of the administration of borax suggests that possibly some of the food was unacted upon by the natural gastric and intestinal ferments, to be subsequently decomposed into useless products by bacterial action.

The experiments throw little light on the effects which borax has been found to produce *in vitro* on amylolysis, but indicate that in the average child between two and a half and five years of age, boric acid and borax may be administered for several days, in quantities equal to, or exceeding, the usual medicinal doses, without any ill effects.

Forster[2] came to similar conclusions after administering about 46 grains of boric acid to a man daily for three days with a mixed diet, and, in another instance, after giving doses of 23 and 7·5 grains of boric acid on two days with a milk diet. He found, however, a small increase in the fæcal nitrogen, which he ascribed to a slightly diminished assimilation, together with an increased intestinal and mucous excretion from the intestine.

The elaborate experiments recently conducted by Dr. Wiley in America, to be referred to later, lead to somewhat different conclusions, but the negative results of the greater number of observations quoted above seem to indicate that these preservatives in moderate quantities exert no prejudicial effect on the average child and adult. Annett's experiments, however, suggest that in infants prejudicial effects may occur, and there is abundant medical evidence to show that in an appreciable proportion of children and adults boric acid has caused serious toxic symptoms, apart from any influence upon the digestive ferments, when administered in ordinary medicinal

[1] As much as 80 grains a pint has been detected.
[2] *Arch. f. Hygiene*, 1884, ii.

doses. As has already been pointed out, boric acid is excreted by the kidneys; if, therefore, these organs are the seat of disease, or are otherwise deficient in excreting power, there is a strong possibility of a cumulative effect being produced. It is well known that this is true with regard to opium, which requires the most careful administration in cases when kidney lesions are present. Young children, too, are extremely susceptible to the action of certain drugs: whether this is the case with regard to boric acid it is impossible to say, as the diseases for which it is usually administered do not obtain in infancy, and digestive derangements are so common in artificially fed babies that it is difficult to ascribe the condition to any one cause—as, for instance, to preservatized milk.

A few instances of the ill effects produced by boric acid may be quoted from the evidence given by witnesses in the Report of the Departmental Committee.

Dr. Handford stated that he had frequently used boric acid in doses of 10 grains three times a day for patients suffering from bladder trouble, but had to suspend it in from 20 to 40 per cent. of the cases on account of digestive disturbances. These effects always disappeared on discontinuance of the drug.

Dr. Briggs Wild administered doses of 15 to 20 grains a day to himself, with the result that after a few days he experienced discomfort after food, loss of appetite, flushing of the skin and general *malāise*. The symptoms disappeared when the drug was left off. On taking quantities up to 120 grains in four hours nausea and diarrhœa resulted. He also mentioned the case of an adult who was taking 10 grains three times a day. After three or four weeks there was a severe eruption spreading from the palms of the hands to the body, face, and head. The hair fell off, and nearly the whole skin was reddened and covered with scabs. This condition was ameliorated as soon as the drug was discontinued; subsequently the treatment was adopted again, with similar results.

Dr. Tubb-Thomas administered boric acid to himself up to

15 grains a day, with the result that vomiting, diarrhœa, headache, and almost complete suppression of urine took place.

Mr. A. R. Anderson stated that the majority of his patients, to whom he had given boric acid for bladder troubles, in doses of 10 to 20 grains three times a day, experienced in about a fortnight pain after food, loss of appetite, nausea, vomiting and skin eruptions, the symptoms disappearing when the drug was stopped. Of his last fourteen patients, eight had found it necessary to discontinue its use.

Similar cases have also been reported from time to time in the medical journals. In the 'Lancet' of January 28, 1899, two instances were given. In the first, 30 grains a day were administered; after 10 days an irritable papulo-erythematous rash occurred on the face, trunk, arms, and legs; the urine was free from albumen. Similar results occurred in the second case, where, in addition to 15 grains taken daily by the mouth, the bladder was washed out with boric acid. In both instances the symptoms disappeared when the drug was stopped.

In the 'British Medical Journal' of the same month, a case is mentioned in which a patient, who was taking up to 60 grains of boric acid a day for three weeks, became entirely bald, and was covered with an erythematous rash.

In the same journal (June 7, 1899) another case is described, in which nausea and dryness of the skin were caused by rectal irrigation with boric acid of a strength of a drachm to a pint. They ceased when the injections were discontinued.

As regards the ill effects of boron preservatives when mixed with foods, some were quoted by witnesses before the Departmental Committee.

Dr. J. H. Jones stated that a delicate lady was suffering from dyspepsia: the milk and butter were examined and found to contain boric acid (to the extent of 1·3 per cent. in the case of the butter). The symptoms disappeared when a purer supply was obtained.

Dr. Tubb-Thomas related instances of children suffering

from diarrhœa, not occurring entirely in the summer, to whom he gave small doses of boric acid; instead of recovering, they became worse, and some of them died. It was found that the milk they were taking contained from 40 to 120 grains of boric acid per gallon. Children in similar circumstances, but having different milk supplies, escaped.

He had also met with cases of phthisis in which the patients had had to give up milk on account of the diarrhœa it caused. The milk was found to contain boric acid. When a fresh supply of milk was obtained, the patients were able to take it without ill effects.

Probably the most striking instance of the ill effects producible by boracic acid was furnished by Dr. E. Hope. A lady had made arrangements with her milkman to supply *pure* milk for the use of her child. Expense was no object, and all the cows were examined by a veterinary surgeon. The child was taken violently ill one day, and it was ascertained that on that particular occasion the milkman had added boracic acid to the milk. Careful inquiries were made as to the possibility of the illness being due to any other article of food, but everything indicated the milk as the cause. The fact that a preservative had been added on that day is, however, suggestive of the milk not being the same as that usually supplied, or of its having shown signs of undergoing some change. However, Dr. Hope was strongly of opinion that the preservative was the cause of the illness.

A far more serious aspect of the case is the alleged effect of borax and boracic acid on the kidneys. In 1901 Dr. Kister, of Berlin, published the results of his observations on the administration of boracic acid to strong and healthy subjects. He found that doses of 40 to 50 grains a day produced albuminuria in four to six days, the albumen persisting until the drug was discontinued. In some instances he found that a dose of 15 grains resulted in vomiting and diarrhœa. With a 15-grain dose, exhibited to a healthy subject, boracic acid appeared in the urine in two hours, but eight days elapsed before the

whole was eliminated. With half the dose the elimination occupied five days. Dr. Charles Harrington[1] conducted a series of experiments on cats, feeding one on food containing no preservative, six on similar food containing borax, and five on the same food containing some other preservatives which proved to be innocuous. The amounts of borax administered are given in the following table:

Weight of borax		Average daily dose	No. of days administered
No. 1	72·5 grammes	0·54 gramme	133
„ 2	112·0 „	0·84 „	133
„ 3	28·0 „	0·66 „	42
„ 4	108·0 „	0·81 „	133
„ 5	106·5 „	0·80 „	133
„ 6	48·0 „	0·85 „	56

Three of the above six cats became ill. No. 3 died at the end of the sixth week, but the others remained active till the end of the experiments. The eleven remaining cats were killed. The organs of the six cats which had not received borax were healthy. In the case of those to which borax had been administered, the kidneys were in all, except No. 2, found to be affected with nephritis of varying degrees of intensity. The epithelium of the tubes, especially the convoluted tubules, was degenerated, and in the lumen of many of the collecting tubules there were granular masses of fragments of cells. Some tubules were almost entirely destroyed. This is fairly conclusive evidence that excessive amounts of borax are harmful, but it does not follow that, because 0·54 to 0·85 gramme (8 to 13 grains) administered daily to a cat causes nephritis, the same amount taken by a healthy adult would have the same effect. The difference in body weight is very considerable, and the human kidneys may possess greater powers of elimination than those of the cat. Still, taken in conjunction with Dr. Kister's observations, there is little doubt

[1] *Lancet*, September 17, 1904. Quoting from the *American Journal of the Medical Sciences.*

that doses of 40 to 50 grains per day are not without effect upon the human kidney. It is very doubtful, however, whether any individual ever takes for any considerable period in his food more than 10 to 15 grains of borax or its equivalent of boracic acid per day on a mixed diet, and the kidneys of a healthy individual may be perfectly capable of eliminating this amount without suffering any damage. This view appears to be borne out by the results recorded by other observers. Dr. Merkel, of Nuremberg, administered 15 to 30 grains of boracic acid to a number of invalids for periods varying from two to eight days, and found they were much more sensitive to the action of the preservative than healthy persons. The amounts above mentioned caused excessive formation of gas in the stomach and intestines, with eructations, colic, epigastric pain and diarrhœa, but he records no production of albuminuria or any symptom pointing to irritation of the kidneys. In the most elaborate and extensive series of experiments yet recorded, carried out by the United States Department of Agriculture, Dr. Wiley, in his report, affords no evidence of any affection of the kidneys having resulted from the prolonged use of moderate quantities of borax. This report is of such interest that a brief reference to it must be made here.

The details are derived from Circular No. 15 of the Bureau of Chemistry of the United States Department of Agriculture, this in its turn being a digest of 'Bulletin No. 84' made by Dr. H. W. Wiley, Chief of the Bureau. Bulletin No. 84 contained several hundred pages, and as, under the existing law, 1,000 copies of such a report is the largest number which can be published, Circular No. 15 was prepared for general circulation. Although it gives the general outline of the experiments and of the results arrived at, it is lacking in certain details which were no doubt present in the full report. There is, for instance, no detailed information as to the actual dosage of borax given day by day or week by week to the twelve volunteers who offered themselves for experiment, the quantities employed being mentioned only in general terms,

nor does it give the ages of the recipients, nor the exact periods during which the observations were maintained.

A large number of young men offered themselves as subjects for the investigations, and twelve were selected. Each applicant was required to answer certain questions as to his health and habits, and only total abstainers were chosen. The moderate use of tobacco was not forbidden.

The selected subjects were boarded at a special 'hygienic table,' but otherwise continued their usual vocations during the whole period of the experiment. They were placed upon their honour to observe the rules and regulations prepared by the Bureau of Chemistry, and to use no other food or drink than that provided, with the exception of water, and any water consumed away from the hygienic table was to be measured and reported. They were to continue their regular habits, and to indulge in no excessive amount of labour or exercise. After the experiments were over, each of the selected subjects was required to certify that these requirements had been kept, and that the data as regards weight, temperature, and pulse-rate had been accurately recorded by him.

The maximum duration of the experiment was to be six months, though in point of fact the periods during which the candidates were actually kept under observation varied from thirty to seventy days. Periods of rest were given during which they were permitted to eat moderately at tables other than those of the Bureau of Chemistry. The hours of meals were: breakfast, 8 A.M.; luncheon, 12 noon; dinner, 5.30 P.M.; the luncheon being only of a light character, with no meat. The meats were selected from roast beef, beefsteak, lamb, veal, pork, chicken, and turkey. Fish and oysters were given, and eggs twice a week. The butter was of the best quality, and free from colouring matter and salt. When preserved vegetables, fruits, or meats were unavoidable, such as had been preserved by cold storage, sterilization, or without antiseptics were selected. Assurances to this effect were required from the purveyors, and the products were examined

chemically from time to time. Tea and coffee were allowed in moderation.

The observations were divided into three divisions, the fore period, preservative period, and after period. The time assigned to each of the periods varied, and the total time varied from thirty to seventy days. During the whole of this time the rations of each member of the 'table' were weighed or measured, and the excreta collected.

Before the fore period was commenced, a note was made of the quantities of food voluntarily consumed by each of the candidates, and from these the proper amount necessary in each case to maintain a comparatively constant body weight was calculated. When a suitable result was thus arrived at, the same quantity of food was given daily during the preservative and after periods.

The preservative was administered in the form of borax and boric acid. At first it was mixed with the butter, but subsequently it was given in gelatine capsules (due allowance being made for the food value of the gelatine). This method was found to be necessary from the fact that when the preservative was mixed with the food in such a way as to conceal its physical appearance, a certain dislike of the food with which it was supposed to be incorporated was manifested by some of the members of the table. 'Those who thought the preservative was concealed in the butter were disposed to find the butter unpalatable, and the same was true with those who thought it might be in the milk or coffee. When, on the other hand, the preservative was given in the capsules with the full knowledge of the subject, much less disturbance was created.' Preliminary experiments with the capsules showed that the gelatine was dissolved in a few moments by the digestive ferments.

The doses of preservative given at first were small, and approximately such as would be consumed in eating foods, such as butter and meat, which had been preserved with borax. The quantity was progressively increased in order to reach the

limit of toleration for each preservative and for each individual. For each variation of the quantity given a separate study of the digestive processes as influenced by the preservative was made.

At the end of the preservative period the after period began, approximately the same quantities of food being given as during the preservative period.

During the entire time, from the beginning of the fore period to the end of the after period, the foods were weighed or measured and analysed, and the excreta collected and analysed.

The candidates were kept under medical supervision, being examined once a week, and treated when necessary for ailments, such as influenza, when these occurred. The blood of the members of the special table was examined periodically as regards colouring matter and number of corpuscles.

The subjects of the experiment themselves kept a record of the sublingual temperature before and after dinner each day, and at the same time counted the pulse rate. A daily record of the body weight was also kept.

Dr. Wiley points out in his report that, although it is not possible to collect every particle of the nitrogen, phosphorus, and sulphur excreted from the body, and so ascertain the exact fate of these elements ingested as food, yet, if a relation can be established between the total amount of these substances entering the food and that leaving the body in the urine and fæces, any disturbance in the relation due to the addition of an abnormal constituent of the food, such as a preservative, can be easily detected. He considers it fair to assume that in spite of the difficulties encountered, any slight errors which may have occurred did not materially affect the conclusions based on the data as a whole.

It is further pointed out that the regular habits of life entailed by the conditions of the experiment led to a high standard of general health among the members of the experimental table, in spite of a few temporary ailments such as

olds and influenza. Consequently it is not impossible that an nfavourable tendency, which might have been caused by the reservative in the case of persons leading a less regulated life, vas counteracted by the good physical condition of the subjects f the experiment.

Any unfavourable mental influences were as far as possible ounteracted by the open administration of the preservative in apsules, in order that a dislike of any particular preservatised ood should not be raised, and in addition the young men were autioned to avoid discussing the development of any ymptoms which they might rightly or wrongly attribute to he drug administered. It was found, as a matter of fact, that fter the first day or two such mental influences were not oticeable.

The experimental data are not set out in Dr. Wiley's eport, but the magnitude of the undertaking is indicated by he fact that the observations were extended over a period of 96 days, in which time analyses were made of 2,550 food amples, 1,175 urine samples, and the same number of fæces amples. In addition, 125 samples of urine and 60 samples of lood were examined microscopically.

As regards the average ratio of food consumed to the body veight, the following figures are given by Dr. Wiley:

—	Moist food, including water consumed	Water-free food
Fore period . .	4·20 per cent.	0·96 per cent.
Preservative period .	4·22 ,,	0·99 ,,
After period . .	4·21 ,,	1·01 ,,

In every series of the experiments there was a marked endency on the part of the preservative to diminish slightly he weight of the body. As a rule this loss of weight ontinued during the after period, though in some instances he loss was checked and occasionally partly regained in the fter period.

On an average about 80 per cent. of the preservative was xcreted by the kidneys, only small traces being found in the

fæces, and, unless the remainder was retained in the body it was presumably excreted in the perspiration.

During the course of the observations 607·4 grains of either boric acid or its equivalent of borax were administered, and 468·69 grains were recovered in the urine, being 77·16 per cent. of the whole. The percentage actually varied in different instances from 63·87 to 83·05 per cent.

The effect of the preservative on the composition of the fæces was in general to slightly increase them both as regards water and dry matter. There was, however, no tendency to excite diarrhœa.

On nitrogen metabolism the administration of boric acid had very little influence, but taking the results of all the observations there appeared to be a decrease in the excretion of nitrogen during the preservative period, and a still greater decrease after the withdrawal of the preservative. Thus, during the fore period, 94·2 per cent. of the nitrogen taken in the food was recovered, as against 93·6 per cent. in the preservative, and 90·1 per cent. in the after period. It is suggested that there may be a tendency of the preservative in large amounts to increase the formation of insoluble compounds of nitrogen, and thus to retard its elimination.

As regards phosphorus the combined results of all the observations indicated that the preservative increased the excretion of phosphorus from 97·3 per cent. in the fore period to 103·1 per cent. in the preservative period, the percentage dropping to 97·0 in the after period.

The metabolism of fat appeared to be practically uninfluenced by the administration of the preservative, but there was evidence of a slight tendency for the boric acid to interfere with the combustion of food in the body, the tendency being most marked in the after period. Combining the results of all the data, 6·4 per cent. of the combustible material in the food was eliminated unburned during the fore period, as against 6·6 per cent. during the preservative and 7·0 per cent. during the after period.

The experiments showed that the boric acid tended to increase the total solids in the fæces and to decrease those excreted in the urine—that is to say, that the preservative interfered with the processes of digestion and absorption. The daily averages were as follows:

—	Quantity of solid food	Percentage in fæces	Percentage eliminated in urine
Fore period . .	631·5 grains	4·1	10·2
Preservative period .	627·6 „	4·6	9·5
After period . .	614·1 „	4·6	9·1

The figures in the third column, it should be noted, include the boric acid administered during the preservative period, and as the drug is excreted chiefly by the urine it would tend to increase the solids in the urine.

As regards the effect of the preservative on the composition of the urine it was found that whilst 85·7 per cent. of the nitrogen was excreted in the fore period, the figure dropped to 85·1 and 81·1 per cent. in the preservative and after periods respectively.

The acidity was increased or reduced according as to whether boric acid or borax had been administered, and in some cases the reaction became alkaline, thus indicating that a large part of the borax was excreted unchanged.

In the few instances where the urine contained a trace of albumen before the experiments, there was a tendency for this to be increased in both the preservative and after periods.

No influence appeared to be exerted on the substances found by a microscopical examination of the urinary deposits.

Similarly no conclusions could be drawn as to any influence of the preservative on the corpuscles and hæmoglobin of the blood.

The effect of boracic acid and borax on the general health varied with the amount administered. Quantities not exceeding ½ a gramme of boracic acid, or its equivalent of borax, given

daily produced no immediate effects. The long-continued exhibition of such small doses appears to have produced the same results as the use of large doses extended over a shorter period. In many instances there was a manifest tendency to diminish the appetite and to produce a feeling of fulness and uneasiness in the stomach, and in some cases actual nausea was experienced. There was a further tendency to produce a sense of fulness in the head, manifested as a dull and persistent headache. These symptoms disappeared when the use of the preservative was abandoned. The continued administration of boracic acid to the amount of 4 or 5 grammes per day (or its equivalent of borax) resulted in most cases in loss of appetite and inability to perform work of any kind. In many cases the person became ill and unfit for duty. The administration of 3 grammes per day produced the same symptoms in many instances, although it appeared that the majority of the men under observation were able to take 3 grammes a day for a somewhat prolonged period and still perform their duties. They commonly felt injurious effects from the dose, and it is reasonable to assume that a normal man could not long continue to receive 3 grammes (46 grains) per day. In some cases 2 grammes and even 1 gramme per day appeared to cause illness, but it is acknowledged that these persons may have been suffering from influenza.

The administration of borax and boracic acid to the extent of one-half gramme per day yielded results markedly different from those obtained with larger quantities. The experiments with this quantity extended over a period of fifty days, and on the whole the results are said to be 'that one-half gramme per day is too much for the normal man to receive regularly,' although for a limited period there may be no danger of impairment of health.

Dr. Wiley sums up his conclusions in the following sentence:

'It appears, therefore, that both boracic acid and borax, when continuously administered in small doses for a long

period, or when given in larger quantities for a short period, create disturbance of appetite, of digestion and of health.'

Dr. Wiley's report and conclusions have recently been exhaustively criticized by Liebreich, who has had the opportunity of visiting Washington, of examining the building in which the men experimented upon were boarded, and of studying all the documents relating to the investigation. He points out that the results were so indefinite, and the number of persons under control so small, that 'one case of self-deception or forgetfulness only would throw into absolute uncertainty the solution of the whole question.' The premises used were not very suitable, being near kitchens and store-rooms for malodorous oils, and possibly 'continuous eating in such rooms would tend to diminish the appetites of young men, especially those who are used to something better, and lead to the changes in metabolism attendant upon this decrease.' The fore-periods were, according to Liebreich, in nearly all cases too short to permit of the normal metabolism being ascertained, and far too much reliance was placed upon chemical results and too little on medical observation. The diminution in weight, 680 grammes for each person (about $1\frac{1}{4}$ lb.), has little significance, and in fact may actually have indicated an improved general condition of the body due to the dieting and regular habits insisted upon. The preservatives were given as a single dose daily in a gelatine capsule, and not mixed with the food at each meal. This, in Liebreich's opinion, renders the whole results unreliable, as the effect of many substances—mustard, salt, and alcohol, for example—is very different if taken alone to what it is if they are taken well diluted in articles of food or drink. A very significant admission is also made by Dr. Wiley. He says, 'The unfortunate fact that many of the data are contradictory must be accepted without question. As the judge and the jury, in the light of contradictory evidence, seek to decide which is the more trustworthy, so have the data herein contained been interpreted

[1] *Third Treatise on the Effects of Borax and Boric Acid on the Human System*. London, J. & A. Churchill, 1906.

with a view, if possible, to giving the greater weight to those which deserve the greater credit.' Another admission of great interest and importance is also made. He says, 'It is, nevertheless, an interesting fact to note that at the end of the year, after the final "after period" had been passed, they [the men experimented upon] appeared to be, and declared themselves to be, in better physical condition than when they entered upon the experimental work seven months before.'

We cannot do better than give Liebreich's final conclusions, since they briefly summarise the whole matter, and appear to us, from a careful consideration of Wiley's Tables as given by Liebreich, to be perfectly fair and reasonable:

Final Conclusions[1]

'The conclusion drawn from an exhaustive examination of the figures and reports drawn up by Dr. Wiley is that no injurious effect was produced by the administration of the boron preservatives. The symptoms of ill-health noticed during the attendance at the Borax-table must be attributed to inefficient hygienic conditions, and to an injudicious mode of administering the preservative, as well as in a few cases to an unsuitable choice of persons for this experiment in spite of medical examination.

'1. With regard to weight, Dr. Wiley assumes that a loss of weight resulted. The average loss of 680 grammes is so slight that it need not be ascribed to the use of boric acid and borax, but can be explained by chance occurrences at the preservative table. Moreover a loss of weight does not by any means always mean an injurious influence.

'2. The experiments on metabolism were undertaken with no equilibrium of nutrition.

'3. The fore periods were too short to prove regularity in feeding.

'4. The percentages of nitrogen and phosphoric acid in the food were constantly changing. Consequently

[1] *Op. cit.* p. 69.

'5. It is impossible to decide whether the excretion increased during the preservative period.

'6. Dr. Wiley calculates the elimination of phosphoric acid in percentages. This method of reckoning is a fault in calculation when the supply of phosphoric acid is not constant, the more so that Dr. Wiley's figures are obtained promiscuously from positive and negative phosphoric acid balances in the fore period.

'7. On considering the separate tables we see that, in the rise and fall of the elimination of phosphoric acid, there is no connection between the magnitude of the dose of preservative or the number of days in the preservative period. and the amount of the elimination of phosphoric acid.

'8. The hygienic arrangements were not on a scale to do justice to every individual.

'9. The medical supervision and self-supervision were not sufficient for experiments of this kind.

'10. The administration of the preservative—that is, of borax and boracic acid in capsules—allows of no conclusions as to the effect of borates when added to food.

'11. It is not necessary to go into the question of calories. Dr. Wiley's own words explain this best. He says: "The data are not wholly decisive, but very suggestive." He does not say why they are suggestive, and he himself adds that his investigations were not exhaustive enough.

'12. No lasting injury to health was found, in spite of transient disturbances caused by the room used for experiment and the administration of the boron compounds in capsules. On the contrary, all the persons declared themselves to be in better physical condition after seven months than they had been before.'

Assuming Dr. Wiley's conclusions to be justified it seems probable that no inconsiderable amount of ill-health, arising from disturbances of the digestive functions, may be due to the preservatives contained in articles of food, milk, butter, bacon,

&c., and yet the cause be rarely suspected, and still more rarely admit of proof. Certainly this has not been proved at present, but now that the attention of the medical profession is being directed to this subject it is possible that the causal relationship, if any, between indigestion, anomalous skin eruptions, and kidney affections, and the use of boracic or other preservatives may be established.

Whether boron compounds, when used in reasonable quantities as food preservatives, have any deleterious effect upon healthy individuals or not, there are two widely prevalent conditions which especially contra-indicate their use, namely kidney affections and atonic dyspepsia, and although there is no evidence of any weight with reference to the action of boric acid on the uterus, the possible danger to pregnant women should not be overlooked. The digestive functions of children being more easily disturbed than those of adults, there is nothing unreasonable in assuming that these preservatives will be more likely to be harmful to children than to adults.

The action of boron compounds has been dwelt upon in some detail because they are more largely used than any others as preservatives in a greater variety of foods, and because the greatest diversity of opinion has hitherto prevailed with reference to their action upon the human system.

CHAPTER IV

CHEMICAL PRESERVATIVES (*continued*)

Formaldehyde

THIS preservative has to some extent supplanted boric acid in the case of milk and cream, but is not much employed for other articles of food, though it is occasionally painted or sprayed over the surface of meat, fish, and fruit, and it has been found in temperance beverages such as ginger beer.

In a pure state it is a gas, but it is usually sold under the name of formalin, which consists of a 40 per cent. solution in water or dilute alcohol. It is sometimes purchased for dairy purposes in a weaker solution, such as 1 per cent. It does not keep well, as it readily undergoes oxidation into formic acid, and is also apt to polymerize. One of its most remarkable properties is its power of hardening albuminous substances. Apparently it is able to enter into combination with proteid material, which is thereby generally rendered insoluble and less easily acted upon by ferments. Serum albumen, however, is an exception to the rule, and remains soluble in water, but it is not coagulable by heat after it has been exposed to the action of formaldehyde.

Cassal[1] found that gelatine, by the addition of 0·1 to 0·5 per cent. of formalin (0·04 to 0·2 per cent. formaldehyde), became hard and horny, and would not dissolve in water, whilst egg albumen was converted into a gelatinous mass insoluble in water, after a few drops of a similar solution had been added.

[1] Report of Departmental Committee.

According to Weigle and Merkel the casein of formalined milk falls in thick voluminous flocculi, and is rendered insoluble even in the mixture of sulphuric and acetic acid used in Gerber's method of estimating milk fat, and equally so in a medium containing pepsin and trypsin (Benedecenti).[1]

Formaldehyde is an excellent germicide, and is largely employed in the form of a vapour or spray for disinfecting rooms, whilst the solution is used for sterilizing clothing, surgical instruments, &c. A 1 per cent. solution has been found to destroy non-sporing bacteria in less than an hour, and many species are prevented from multiplying by so dilute a solution as 1 in 20,000. Dr. Blaxall[2] found that milk is sterilized by the addition of formaldehyde in the proportion of 1 in 500.

Rideal and Foulerton[3] have shown that the organisms producing the souring of milk are checked for some hours when the proportion is only 1 in 50,000, and consider that this quantity need not be exceeded for practical purposes.

The point at which the milk was deemed unfit for sale in these experiments was the same as that in the case of boric acid, namely an acidity equivalent to 0·25 per cent. of lactic acid. The following table represents the percentage acidity of the milk after the addition of formaldehyde, at various temperatures:

Temperature F.	Milk without formaldehyde				Milk to which 1 in 50,000 formaldehyde had been added			
	15 hours	20 hours	23 hours	39 hours	15 hours	20 hours	23 hours	39 hours
55·4°	0·18	0·18	0·18	0·19	0·18	0·18	0·18	0·17
64·0°	0·20	0·20	0·21	0·39	0·18	0·18	0·18	0·21
75·2°	0·23	0·24	0·28	0·80	0·19	0·20	0·22	0·59

It will be seen that at 75·2° there is a gain of over three hours, and at 64° one of 16 hours by the use of the preservative.

[1] *Zeitschrift für Hygiene und Infectionskrankheiten*, vol. 48, part i.
[2] Report of Departmental Committee.
[3] *Public Health*, 1899.

It is, however, as discussed in Chapter III., open to doubt whether the formation of deleterious products is likewise checked—that is to say, whether lactic acid can be taken as an index of the effect of formic aldehyde on all the organisms which may produce toxic substances in milk. In fact, according to Delépine,[1] more than one part of formaldehyde in 10,000 is necessary to check the multiplication of B. typhosus in fluid media, and a still stronger solution is required in the case of organisms of the B. coli group.

Droop Richmond[2] conducted similar experiments on the same lines as those already quoted in the case of boric acid. The following results are expressed as the length of time during which milk will keep sweet at various temperatures with and without the addition of preservative:

Temperature F.	Formaldehyde added per cent.			
	None	0·0023	0·0047	0·0093
	Hours	Hours	Hours	Hours
60°	50	60	100	140
70°	34	40	58	92
80°	22	29	40	66
90°	15	18	31	52
100°	9	11	27	44

Thus with the addition of 1·15 parts of formaldehyde in 50,000, a gain of 10, 6, and 7 hours respectively, is observed at 60°, 70°, and 80°, whilst with twice this quantity the corresponding figures are 50, 24, and 18 hours.

Bearing in mind the powerful germicidal properties of formaldehyde, one would expect it to produce an inhibitory effect on the digestive ferments. That this takes place to some extent is shown by the experiments of several observers, and the following are a few of the results.

Action on Ptyalin.—Rideal and Foulerton[3] found that, expressing the amount of a given quantity of arrowroot starch

[1] *Trans. Epidem. Society*, Vol. xxii. p. 58.
[2] Report of Departmental Committee.
[3] *Public Health*, 1899.

converted into sugar as 100, the quantity thus produced by ptyalin in the presence of formic aldehyde was as follows :

1 in 100,000 formaldehyde . . .	99·8
1 „ 50,000 „ . . .	96·0
1 „ 10,000 „ . . .	89·0

This effect is apparently due to the action of the preservative not upon the starch, but on the ferment, as Bliss and Novy[1] found that starch which had been exposed to a 1 per cent. solution of formaldehyde for five days behaved to ptyalin exactly like fresh starch.

Action on Pepsin.—Rideal and Foulerton[2] showed that 1 part of formaldehyde in 50,000 inhibited the digestive action of pepsin by 2·4 per cent.

Cassal[3] found that in a solution containing 1 part of formalin in 10,000 (1 in 25,000 formaldehyde), pepsin failed to digest fibrin in six hours, and that an insoluble deposit was formed at the bottom of the flask. In the absence of formalin digestion was practically complete in two and a half hours.

This inhibitory effect increases with the concentration of the antiseptic. Thus, according to Starling,[4] fibrin, which had been exposed to a solution of 1 in 2,500 formaldehyde, was incapable of digestion by gastric juice, and this condition persisted even after the fibrin had been washed for two days in running water.

It appears probable that the effect is due to the action of formaldehyde more on the albuminous material than on the ferment, since Bliss and Novy[5] have shown that the antiseptic has no deleterious effect on pepsin even when the latter has been exposed for some weeks to a 4 per cent. solution.

Rideal and Foulerton[6] allowed 15 grammes of beefsteak to stand in 100 c.c. of water to which measured quantities of formaldehyde had been added. After twenty-four hours the meat was digested with pepsin for an hour at 38° C., and the

[1] *Journ. of Experimental Medicine*, 1899, vol. iv. p. 74.
[2] *Loc. cit.*
[3] Report of Departmental Committee.
[4] *Ibid.*
[5] *Loc. cit.*
[6] *Loc. cit.*

dissolved nitrogen estimated, a control experiment being made in which no preservative had been used.

The results were:

Quantity of formaldehyde	Quantity of proteid digested
None	100·00
1 in 100,000	91·45
1 ,, 50,000	90·38
1 ,, 10,000	85·25
1 ,, 2,500	81·19

showing that formaldehyde renders proteid material resistant to pepsin in proportion to the quantity present.

Action on Rennin.—Foulerton[1] found that a quantity of formalin, equivalent to 1 in 40,000 formic aldehyde, delayed the action of rennin a few minutes, 1 in 10,000 about an hour, while when the strength reached 1 in 1,000 the ferment was almost entirely inhibited. Bliss and Novy[2] have shown that formaldehyde may be added to rennet in the proportion of 5 per cent. without destroying the ferment, in which case the results of Foulerton's experiments must be ascribed to the direct action of formic aldehyde on the casein. Lowenstein has recently further investigated this subject and arrives at the following conclusions:[3]

1. Formaldehyde so alters the milk that it no longer reacts towards rennet. The degree of alteration depends, first, on the length of contact, and, secondly, on the strength of the formalin solution.

2. These changes in the milk take place with the small quantities of formalin which are used in practice for preservation.

Action on Trypsin.—It has been shown by Rideal and Foulerton[4] that formaldehyde when present to the extent of 1 in 50,000 has a slightly inhibitory effect on the proteolytic ferment of the pancreatic juice. The amount of fibrin digested in one of their experiments was 97·0 as against 100 in the absence of the antiseptic.

[1] *Lancet*, 1899, vol. ii.
[2] *Loc. cit.*
[3] *Public Health*, April 1905, p. 457.
[4] *Ibid.*, 1899.

Halliburton[1] found that fibrin, which had previously been in contact with a 1 in 2,000 solution of formaldehyde for two days, resisted the action of pancreatic juice three times as long as ordinary fibrin, whilst if the strength of formaldehyde was doubled no digestion took place in twenty-four hours.

Bliss and Novy[2] have shown that this ferment is itself destroyed by a 1 in 500 solution of formaldehyde, and inhibited by one half this strength, apart from any action which the antiseptic may have upon the proteid substances to be digested. In this connection Rideal and Foulerton exposed milk for twenty hours to the influence of varying quantities of formaldehyde, and then digested the mixture with extract of pancreas. After half an hour the quantity of casein dissolved was estimated, with the following results:

Quantity of formaldehyde	Quantity of casein digested
None	100·0
1 in 100,000	94·6
1 „ 50,000	94·1
1 „ 10,000	91·4

Possibly, if digestion had been carried on for a longer period, a larger proportion of the casein would have been dissolved.

Action on Amylopsin.—The same observers, using two different samples of this ferment, found the effects of the addition of varying quantities of formic aldehyde to be as follows:

Formaldehyde added	Starch converted into sugar	
	Ferment A	Ferment B
None	100·0	100·0
1 in 100,000	96·4	87·2
1 „ 50,000	91·8	84·2
1 „ 10,000	91·5	83·0

Starling[3] found that 1 in 5,000 formalin (equivalent to 1 in 12,500 formic aldehyde) entirely stops the action of pancreatic juice.

[1] Report of Departmental Committee.
[2] *Loc. cit.* [3] Report of Departmental Committee.

No observations have been recorded as to the action of formic aldehyde on Succus entericus, or on the emulsifying agents in bile and pancreatic juice, but it will be gathered from the experiments just recorded that *in vitro* all the principal natural digestive enzymes are retarded to some extent by formic aldehyde even in such small proportions as 1 part in 50,000. The effect seems to be most marked in the case of amylopsin—a most important ferment in the digestion of farinaceous food—and least in that of pepsin.

In addition there appears to be a specific reaction, of the nature of a chemical combination, between the preservative and albuminous material, whereby the action of proteolytic ferments is retarded.

There is thus a considerable contrast between boron compounds and formalin, as, in the case of the former, the action of many of the digestive ferments appears to be actually favoured.

Nothing is known as to whether formaldehyde, in such weak solutions as those necessary for the preservation of food, has any direct effect on the secretory cells of the digestive tract. In concentrated solutions it undoubtedly has a depressing influence on their vitality, and it is possible, therefore, that this may take place when the substance is present in such quantities as those used in the foregoing experiments, in which case an additional inhibitory effect would be added.

A few experiments have been carried out on animals in order to ascertain how far formaldehyde exerts a prejudicial effect on nutrition.

At the South-Eastern Agricultural College at Wye[1] observations, similar to those already mentioned in the case of boracic acid, were made on six young sucking-pigs. They were kept under observation until it was found that their rate of growth was steady, and were then matched in three pairs. The pigs in each pair always received equal weights of the same food, but one of them was given a dose of formalin suitably diluted. The experiments lasted over seven weeks, the

[1] Report of Departmental Committee.

initial daily dose of formalin being 2 c.c. (= 0·8 gramme formaldehyde), this being afterwards increased to 4 c.c.

At the end of the time no deleterious influence was observed on the pigs to whom formalin was administered, and they grew rapidly, and fed as well as those to whom none was given. The formaldehyde represented a concentration varying from 1 in 185 to 1 in 730 of the total food. Annett[1] obtained different results by using, as in the case of boric acid, very young kittens, taken as far as possible from the same litters, for his experiments.

A set of five kittens received milk containing 1 part in 50,000 of formaldehyde, for seven weeks, whilst another set of four were fed on pure milk. Of the former, three died, and the average increase in weight per kitten was 177·6 grammes, as against 251·1 grammes in the case of the latter set. Annett considers this to indicate a retarding effect on nutrition to the extent of 29·3 per cent.

Similar experiments were made using milk containing twice this quantity of formaldehyde, with a result that the increase of weight was retarded by 39·6 per cent. None of the kittens succumbed.

With a concentration of 1 in 12,500, two kittens died, and there was a retardation in weight of 69·1 per cent.

In no instance was the quantity of milk controlled, the kittens being allowed to take as much as they wished.

Rideal[2] has criticised these experiments, pointing out that the results were extremely irregular in comparison with the number of kittens used, and that cow's milk is an unsuitable diet for these animals. Nevertheless the fact remains that five of the kittens fed on formalined milk died, whilst none of the controls shared this fate, and many of the former had symptoms such as loss of appetite, diarrhœa, gaseous distension of the abdomen, and changes in the fur, chiefly in the direction of roughening. Moreover, the loss of weight increased *pari passu* with the concentration of the preservative.

[1] *Lancet*, 1899, vol. ii. [2] *Ibid.*, 1900, vol. i.

Rideal repeated the experiments by feeding kittens five weeks old with 70 c.c. of milk containing 1 in 5,000 formaldehyde daily, but could detect no injurious effects.

As has already been stated, the digestive processes in man and animals differ considerably, and it is not safe to attach any great importance to such feeding experiments.

Observations as to use and effects of formaldehyde on the nutrition of children were made by Tunnicliffe and Rosenheim.[1] The same children to whom boric acid had previously been administered were employed for this purpose, the experiments lasting twenty-eight days in the case of the two healthy boys, aged two and a half and five years respectively, and twenty-one days in that of the delicate girl, aged four years. A mixed diet was given, and in each instance there was a fore and an after period of seven days. During the intervening fourteen or seven days formaldehyde was administered.

In the case of the boys formic aldehyde was given in the morning and evening milk for seven days, in the proportion of 1 part in 10,000, the total quantity being 0·05 gramme of formic aldehyde per diem; the evening milk had been exposed to the action of the preservative for about nine and a half hours. During the next week twice this quantity was administered, partly in the milk, and partly with the meat at dinner.

In that of the girl 0·1 gramme of formic aldehyde per diem was given, partly in the milk (in which it reached a concentration of 1 in 5,000), and occasionally in the meat, for a period of seven days.

The constituents of the foods were ascertained by analysis, and the nitrogen, uric acid, sulphuric acid, &c., of the urine, and the nitrogen and fat of the fæces determined.

The general conclusions arrived at were as follows:

'1. In healthy children formic aldehyde administered with the food in doses up to 1 : 5,000 in milk, or 1 : 9,000 in total

[1] *Journal of Hygiene*, vol. i. p. 321.

food and drink exerted no appreciable effect on the nitrogen, or phosphorus metabolism, or on fat assimilation.

'The analytical figures suggest, however, that formic aldehyde has a tendency to diminish phosphorus and fat assimilation, and hence it may be inferred that in larger doses, or if continued for a longer period, it would act in this direction. The effect is referable to an influence upon pancreatic digestion.

'2. In healthy children formic aldehyde in the above doses produces a retention of water in the body.

'3. In a delicate child formic aldehyde in the above maximum dose had a chemically measurable deleterious effect upon the nitrogen, phosphorus, and fat assimilation, again referable to an action upon the pancreatic digestion, combined with a slight intestinal irritant action. There was a slight tendency to stimulate the katabolism of proteid material.

'4. In a delicate child formic aldehyde increased the volume of urine and the weight of fæces.

'5. In all cases the excretion of lecithin in the fæces was diminished under the influence of formic aldehyde. This effect is probably referable to a stimulating action of formic aldehyde on the lecithin-splitting ferment of the pancreas.

'6. In no instance did formic aldehyde exert any appreciable intestinal antiseptic action.

'7. In no instance was there any influence on the general health or well-being of the children.'

It will be observed that these conclusions are distinctly less favourable than those in the case of boric acid, when the results were practically negative, and this in spite of the comparatively short time during which the observations were carried on.

If, however, we take 0·1 gramme of formaldehyde to be the maximum dose permissible for a healthy child of two and a half years, that for a baby of six months would be about one-fifth, or 0·02 gramme. This quantity would be contained in less than two pints of milk, supposing that the preservative

were added to the extent of 1 part in 50,000, and the child would therefore be taking daily the maximum dose of formaldehyde permissible, whilst this would, of course, be exceeded unless great care were taken to prevent an increase in the quantity of antiseptic added. If the child were a delicate one, even one-fiftieth of a gramme might possibly have deleterious effects on nutrition.

Since formic aldehyde is rarely, if ever, administered as such by the mouth medicinally its ultimate fate in the body has been but little studied.

Both formaldehyde and formic acid have been found in the urine of rabbits to which the former drug has been administered, and apparently oxidation takes place to some extent in the liver. Urotropine, the ammonium compound of formic aldehyde, is excreted unchanged in neutral and alkaline urines, and as formic aldehyde in acid urines.

This drug is frequently given to disinfect the urinary passages in cases of cystitis, and also in enteric fever, the usual dose being about 30 grains a day, without ill results.

Formalin is sometimes administered as an inhalation in cases of phthisis and septic conditions of the lung, any deleterious effect being usually in the direction of causing irritation to the air passages.

In Dr. Maguire's Harveian Lectures[1] an instance was mentioned in which 50 c.c. of a 1 in 2,000 solution of formaldehyde were injected intravenously for phthisis without any toxic symptoms arising.

Vomiting and death in twenty-nine hours occurred after about two and a half grammes of this substance had been taken by a youth in the form of a 4 per cent. solution,[2] whilst Hehner[3] experienced violent abdominal pains, lasting for some days, after taking milk which contained 1 in 5,000 parts of formalin (1 in 12,500 formic aldehyde).

[1] *British Medical Journal*, 1900, vol. ii.
[2] *Medical Press*, 1899, p. 309.
[3] Report of Departmental Committee.

After a consideration of the experimental evidence on the hardening effects of formic aldehyde on proteids, its action on the various digestive ferments, and the observations on the effect of its administration to newborn kittens and to children, it is difficult to resist the conclusion that this antiseptic has powerful properties even when highly diluted, and, if used at all for preserving food, should be very carefully employed in order to prevent deleterious effects in the digestive processes of the consumers.

Comparing it with the boron compounds, experiments seem to show that it exerts on the whole a more prejudicial effect on the digestive ferments, and on the nutrition of children, whilst evidence as to any possible toxic effects, when dilute solutions are used, are at present wanting, except such as are referable to direct irritation of the mucous membrane of the alimentary tract.

The possibility of skin disease being caused by the continued use of milk preserved by the addition of formalin is suggested by Dr. Moncton Copeman's Report to the Local Government Board on an outbreak of Epidemic Skin Disease amongst inmates of the Central London Sick Asylum, Hendon, in 1903.

Some sixty-eight of the inmates were affected, and two of the cases terminated fatally. The epidemic was confined entirely to the patients of the institution, and chiefly to those of comparatively advanced age, who were subjects of various chronic ailments. The porters, officials, and nurses (with two possible exceptions) were unaffected.

The eruption was chiefly erythematous, but in some of the patients it was papular or even bullous, whilst in many instances pustules, chiefly in connection with the hair follicles, occurred. All parts of the body were liable to attack, though in most of the patients the eruption was more or less localized, the forehead and scalp and the trunk being the principal seats. Desquamation, frequently very profuse, took place, and the rash was accompanied by much irritation.

Sources of local irritation, such as coarse body clothing, bad soap, or newly dyed bedding, infection from without, and personal infection, having been excluded, Dr. Copeman turned his attention to the food supplied to the inmates. Milk, bread, and butter were found to be the only foods which were partaken of by practically all the inmates of the infirmary. The bread was of good quality, as was also the butter; moreover, one of the inmates affected disliked butter, and had eaten none for over two months prior to the outbreak.

A few cases occurred in June and the first half of July 1903, but the disease only showed itself in epidemic form in the last week of July, continuing till the end of September, when it abruptly ceased.

Suspicion having been thrown upon the milk supply, the patients were given Swiss milk, and the milk contract was transferred on October 4 to new hands, and at an increase in price of 4½*d.* per barn-gallon.

At least half a pint of milk is included in the dietary of nearly all the patients in the infirmary, and amongst the few who had certainly consumed no milk there was no instance of the occurrence of the skin disease. Previous attacks of eczema appeared to predispose to subsequent attacks of the special ailment.

The milk was supplied by a contractor, and was derived partly from his own cows and partly from other sources. Milk, kept at the Asylum in open graduated tubes for the purpose of estimating the amount of cream, was noticed to remain uncurdled for three, four, or even more days in July during exceptionally hot weather, and there was, therefore, a strong presumption that a preservative had been added. The steward mentioned that the milk possessed a faint slightly burnt smell, absolutely unlike that of good fresh milk. It was not, however, until September 29 that samples of the morning and evening milk were submitted for analysis. They were of somewhat poor quality, especially as regards the non-fatty solids, whilst the ash was unusually high. Neither boracic

nor salicylic acids were present, but both samples contained traces of formalin.

Strong presumptive evidence was therefore obtained connecting the epidemic with the milk supplied and with the presence of the preservative, but it by no means follows that the formalin was the actual cause.

Similar outbreaks have occurred in other public institutions and have been attributed to the milk, but the possibility of the 'preservative' being the cause does not appear to have been considered in these earlier cases.

CHAPTER V

CHEMICAL PRESERVATIVES (*continued*)

Sulphurous Acid and the Sulphites

SULPHITES, chiefly the acid sodium and calcium salts, are frequently employed for the preservation of beverages such as beer, cider, wines, cordials, lime juice and lemon syrup, and also of various kinds of meat, poultry, and game, and they have been found in other food substances such as vinegar, pickles, catsups, anchovy paste, and in desiccated apricots and other fruits (0·2 to 1·15 per cent. of $Na_2SO_3 7H_2O$).

The active principle of the sulphites is the available sulphur dioxide, which is a moderately active germicide, used largely for the disinfection of rooms, and also, in the absence of a steam sterilizer, for articles of clothing. When present to the extent of 1 per cent. of the cubic capacity of a room non-sporing bacteria are killed in a few hours, though it is doubtful whether even a much more concentrated vapour is capable of destroying their spores. Casks to contain beer, wine, or fruits, are often exposed to the action of the gas to ensure surface sterilization.

Sulphites are used medicinally as an application in some parasitic skin diseases, and, although they are seldom administered internally, the dose of the British Pharmacopœial preparation is up to a drachm, which is equivalent to about 0·2 gramme of sulphur dioxide.

Sulphites are obtained commercially for preserving purposes under various trade names. 'Meat preserve crystal' has yielded on analysis both sulphite and sulphate of soda: 'Freeze-em' has been found to contain sodium sulphite with traces of

sodium carbonate and common salt; whilst 'Hawke's Anti-ferment,' a preparation sold to cider manufacturers, consists chiefly of sulphite of calcium with traces of lime.[1] The basic portion, by neutralizing an excess of acid might presumably render an inferior and possibly injurious brand of cider palatable.

Both sulphurous acid and sulphites readily take up oxygen from the air or from liquids in which they are dissolved. Such sulphites as are used for preservatives may, therefore, be gradually oxidized into sulphates, which are comparatively inert. In bottled beverages, however, oxidation would take place very slowly, if at all. The bisulphites used by butchers for dusting over meat and for preserving minced meat in sausages, &c., not only act as an antiseptic, but also as a deodorant and restorer of the red colour of the fresh meat, hence their advantages over the boron compounds and most other preservatives.

The possible effects of the administration of sulphites on the human subject and animals have not been studied in England to any great extent, but they have been inquired into on the Continent, where there is a large consumption of minced meat ('Hackfleisch,' to which reference will be made later) preserved by these substances, and in America Dr. Charles Harrington,[2] Assistant Professor of Hygiene, Harvard Medical School, has collected a large number of facts, and added to them the results of his own experiments. It is from his work on the subject that the greater part of the following information is derived.

Since sulphur dioxide is readily liberated from sulphites by the action of dilute acids, this dissociation will presumably be effected by the acids present in gastric juice, the extent being largely dependent on the amount of free acid present. Hyperacidity is by no means an uncommon condition in certain kinds of dyspepsia, and in such cases eructations

[1] Report of Departmental Committee.
[2] *Boston Medical and Surgical Journal*, pp. 555–59, May 26, 1904.

containing sulphur dioxide, or possibly under certain conditions sulphuretted hydrogen, might be expected. In 1869 Bernatzik and Braun [1] administered 80 mlgm. of free sulphurous acid in 360 c.c. of water, by divided doses extending over twenty-four hours, to each of fourteen women with various disorders of pregnancy. In twelve of the patients eructations of sulphur dioxide, an unpleasant taste, vomiting, diarrhœa, and general *malaise* ensued, the symptoms lasting for a day.

Doses of 1 gramme of magnesium sulphite were also badly borne, causing vomiting and diarrhœa. The administration of 3·75 grammes of sodium bisulphite caused purging in eight women out of twelve after the first dose.

Bornträger [2] found that eructations of sulphur dioxide and sulphuretted hydrogen, together with discomfort and headache lasting for some hours, were caused as a result of eating certain sausages, or of drinking certain Rhine and Moselle wines containing sulphites.

Pfeiffer [3] applied aqueous solutions of sulphur dioxide to the gastric mucous membrane (presumably of animals), and found that inflammation was set up even by dilute solutions, and that death ensued shortly after the application of a 5 per cent. solution, there being marked corrosion of the layers of the stomach wall, and even of the surface of neighbouring organs.

He also states that half a gramme of sulphite in dilute solution causes oppression and discomfort in himself and others, whilst Leuch [4] asserts that wines containing free sulphur dioxide cause discomfort more readily than those which contain it in combination: 45 mlgm. of the former being equivalent in this respect to 250 mlgm. of the latter. These amounts taken in about two-thirds of a pint of wine caused irritation of the

[1] *Wiener medicinische Wochenschrift*, xix. 1869.

[2] *Die Beurtheilung des Zusatzes schwefligsaurer Salze zum Fleische von Sanitätspolizeilichen Standpunkte*, Leipzig, 1900.

[3] *Archiv für experimentelle Pathologie und Pharmakologie*, xxvii., 1890.

[4] *Correspondenzblatt für schweitzer Aerzte*, 1895, no. 15.

throat and headache. Severe headache and diarrhœa resulted with quantities of 55 and 350 mgm. respectively.

In addition to these subjective symptoms, there is reason to believe that sulphites are liable to cause organic changes in the abdominal organs, especially the kidneys, even though symptoms of poisoning are not at once manifested.

The earliest experiments were those of Kionka in 1896; he reported that repeated small doses administered to dogs produced serious lesions in various parts of the system.

His results were challenged by Liebreich and others, and his experiments repeated by Lebbin and Kallmain,[1] neither of whom was, however, a pathologist. They reported an entire absence of lesions on a post-mortem examination.

A more extensive series of experiments by Kionka and Ebstein[2] confirmed the former's first results, and Schultz[3] obtained similar results. In both series of Kionka's investigations none of the dogs showed any outward appearance of injury, and in fact occasionally gained in weight. Two of Schultz's dogs suffered from purging, but in the end they all increased in weight; nevertheless in every case nephritis was discovered at the autopsy.

Dr. Harrington[4] employed cats instead of dogs, as about 25 per cent. of the latter animals are subject to nephritis when kept caged and in confinement. Six cats were under observation for a period of twenty weeks, one of them acting as a control, the remaining five receiving six feedings weekly of meat containing 0·2 per cent. of sodium sulphite. The control animal showed a constant gain in weight throughout; the others gained till about the ninth week and then began to lose ground, frequently refusing food or leaving it uneaten, but otherwise exhibiting no signs of injury. At the end of twenty weeks they were killed and examined by Dr. Tyzzer,

[1] *Zeitschrift für öffentliche Chemie*, 1901, p. 324.
[2] *Zeitschrift für Hygiene und Infectionskrankheiten*, xli. p. 123.
[3] *Deutsche medicinische Wochenschrift*, 1902, p. 265.
[4] *Loc. cit.*

of the Department of Pathology of the Harvard Medical School. To the naked eye the organs appeared normal, but microscopically the kidneys of all the cats, with the exception of the control, showed inflammatory changes. Among other conditions the kidneys were hyperæmic, the lining cells of many of the tubules, especially those in the medullary rays, showed a marked degree of cloudy swelling, and the cells of the convoluted tubules were loaded with fat. Fibrin was present in the lumen of the tubules, and in one instance there was an invasion of the interstitial tissue with lymphoid and plasma cells. The microscopic appearances of the kidneys of the control animal were normal.

In the case of meat the sodium salt is the one usually employed, and it is applied externally, 0·1 to 0·2 per cent. being the smallest quantity which is likely to produce the desired effect, but even as much as 4 per cent. has been found.[1] As already indicated a slow oxidation takes place with the formation of sodium sulphate, but Gärtner has experimentally recovered from 56·8 to 87·3 per cent. of the original sulphite twenty-four hours after the admixture, whilst Polenski recovered 81 per cent. from a sausage after three months, and from 72 to 77 per cent. after six months.[2]

The action of the sulphite on the meat appears to be threefold. It undoubtedly checks the growth of organisms even when present to so slight an extent as 0·05 per cent., whilst apparently its maximum influence is exerted when it reaches about 0·5 per cent.

Comparing the number of organisms in meat so treated with plain meat, Altschüler obtained the following figures:

—	Plain meat	Treated meat (5 per cent. sulphite).
First day	1,200,000 per gramme	1,200,000 per gramme
Fourth day	1,829,100,000 ,,	2,500,000 ,,
Ninth day	—	300,500,000 ,,

[1] Dr. Charles Harrington, *loc. cit.* [2] *Ibid.*

Dr. Harrington experimented with hashed beef divided into two portions. To the one 0·2 per cent. of sulphite was added, and both portions were kept in a refrigerator under similar conditions. The number of bacteria per gramme was estimated daily.[1]

—	Plain meat	Preserved meat
After 1 day	610,000	1,760,000
„ 2 days	1,045,000	1,600,000
„ 3 „	2,709,000	2,709,000
„ 4 „	6,579,000	3,999,000
„ 5 „	10,346,000	2,322,000
„ 6 „	26,313,000	3,483,000
„ 7 „	Very foul odour	Faint mouldy odour

The salt exerts its influence best when the meat is kept at a low temperature, and apparently quickly loses its power at ordinary room temperatures, having in fact less preservative influence than the low temperature of a refrigerator. Gärtner, as quoted by Dr. Harrington, obtained the following results:

—	Untreated meat kept at 39° F. in a refrigerator
After 24 hours	320,000 organisms per gramme
„ 48 „	575,000 „ „

—	Meat kept at room temperature and treated with 0·09 per cent. of sulphite
After 24 hours	448,750 organisms per gramme
„ 48 „	5,385,000 „ „

—	Meat kept at room temperature and treated with 0·36 per cent. of sulphite
After 24 hours	448,750 organisms per gramme
„ 48 „	678,000 „ „

The number of organisms found in meat to which a sulphite has been added bears no relation to the quantity of preservative present, being no doubt dependent on the number originally

[1] Dr. Harrington, *loc. cit.*

present before the addition. Stroscher[1] examined a number of samples containing from 0·029 to 0·520 per cent. of sodium sulphite with the following results:

Quantity of preservative	Number of organisms per gramme
0·065 per cent.	62,096,000
0·075 "	54,056,000
0·080 "	13,500,000 (approximately)
0·430 "	147,000
0·470 "	14,138,000
0·520 "	50,917,000

The second effect of the addition of sulphite to meat is a remarkable preservation of the red colour, which may even become abnormally bright. This effect is apparently due to the formation and preservation of oxy-hæmoglobin, and is one of the chief incentives to the addition of sulphites to meat. An enormous quantity of minced or ground meat is sold on the Continent under the name of 'Hackfleisch' and in America as 'Hamburg steak.' According to Dr. Harrington this is prepared largely from trimmings and various inferior parts not otherwise saleable, which accumulate in the receptacles for waste at meat stalls, and thereby acquire an extensive bacterial flora. Such meat when treated by the addition of a sulphite looks invitingly fresh even when actually stale and swarming with bacteria. The red colour is most intense on the exterior of the mass, and the interior may be quite dark, though changing to a bright red tint on exposure to the air. It should be noted that even stale meat which has darkened in colour will attain a bright red tint if treated with a sulphite, so long as the addition is made before decomposition has proceeded too far.

A third effect of the preservative is to act as a deodorant, and so mask the foul odours of decomposition. Altschüler[2] found that untreated meat yielded 1,829,100,000 bacteria per gramme at the 'stinking' stage, whilst another portion to which 1 per cent. of the salt had been added was without

[1] Dr. Harrington, *loc. cit.* [2] *Ibid.*

odour until the number of bacteria reached 4,757,000,000 per gramme.

The objections to the use of sulphites in the case of meat are therefore obvious, without even taking into consideration the possibility of injury to health from the action of the preservative on the abdominal organs.

For the preservation of beer the lime and potash salts are those chiefly employed, and, according to evidence furnished to the Departmental Committee, about 1 part in 5,000 is the customary amount. In the case of cider one of the witnesses stated that 1 part in 10,000 was a sufficient quantity. It has also been found in vinegar to the extent of 1 part in 5,000. Although these proportions are small, it must be remembered that both beer and cider may be consumed in large quantities, and if the results of the experiments referred to are applicable to human subjects, even 1 part in 10,000 cannot be regarded as free from the risk of insidiously producing disease of the kidneys and possibly of other organs.

It is somewhat disquieting to find that so many of the preservatives most largely employed for preventing the decomposition of foods are alleged to have an injurious effect upon the kidneys. If proved, this would be a strong argument, if not for refusing to permit the use of such preservatives, at least for limiting their use to the smallest amount possible, and for insisting upon the declaration both of the quantity and character of preservatives present in all articles of food and drink. In any case, were this done, the risks of danger would cease to exist for those who wished to avoid articles containing such preservatives.

CHAPTER VI

CHEMICAL PRESERVATIVES (*continued*)

SALICYLIC AND BENZOIC ACIDS

1. *Salicylic Acid*

DURING recent years it has been discovered that salicylic acid is present in a large number of fruits, and in various odorous flowers. In certain natural wines its presence has been detected, but whether it is derived from the original grapes, or from the grape stalks, or whether it is produced during the fermentation process, has not been positively ascertained. The oil of winter-green contains nearly 90 per cent. of the methyl ester, and it is probably the same compound which occurs in fruits. The acid has been detected in Portuguese, German, and Austrian wines, but the amount is very small, probably not more than 1 mlgm. per litre; in any case a large volume of wine has to be taken for its isolation and identification.[1] It has been detected in the following fruits, and will therefore be naturally present in their juices: strawberries, raspberries, blackberries, currants, plums, cherries, apricots, peaches, crab-apples, and oranges.[2] Des-moulière has estimated the amount present in various kinds of cherries, and finds that it varies from 0·1 to 0·21 mlgm. per kilo-gramme.[3] Up to the present time it has not been found in any fruit in a larger proportion. This quantity is far too small to have any effect as a preservative, but unless its presence is remembered, a wine or fruit juice may be certified to contain it as an added preservative, especially as it is the chief antiseptic employed for jams and other forms of preserved fruit, and also for beverages containing a considerable quantity of sugar

[1] *The Analyst*, vol. xxvi. pp. 274 and 72.
[2] *Ibid.*, vol. xxviii. p. 149. [3] *Ibid.*, vol. xxix. p. 90.

and little or no alcohol, such as cider, perry, beer, British wines, sweetened lime and lemon juice, and syrups, though it is to some extent supplanted by the use of sulphites in the case of beer and cider.

It has also been found in butter, sauces and ketchups, in meat juices, potted meat, and sausages, in sherry, port, ipecacuanha wine, and orange quinine wine.

Occasionally it is employed, either alone, or more usually in conjunction with boric acid, for preserving milk and cream.

Like the other preservatives already mentioned it is generally sold under various trade names. Thus 'Cynin' contains salicylic acid, borax, and glycerine, while 'Walter Gregory's Powder' consists almost entirely of salicylic acid mixed with red oxide of iron.[1]

For pharmaceutical purposes the acid is either obtained from the oil of winter-green or of the sweet birch, or is made by combining phenol with carbonic acid gas, in which case impurities, such as ortho- and meta-creasotic acids, are apt to be included. It is to these impurities, rather than to the acid itself, that many of the ill effects produced when it is used as a drug are to be attributed, since such effects were more frequently observed when the acid was first introduced than has been the case since a far purer article has been on the market.

It is a fairly reliable germicide, a solution containing, according to some observers, 1 in 400, and, according to others, 2½ per cent. of the acid being sufficient to kill non-sporing bacilli in a few hours, but it seems to be unable to destroy anthrax spores. Wool impregnated with the acid is frequently used as a surgical dressing, though, if applied direct to a raw surface, it is apt to produce irritation.

It is a good antiseptic, its action in this respect being well marked when it reaches a strength of 1 in 1,000, and it appears to have the power of inhibiting especially the growth of moulds and of those organisms which cause fermentation in preparations of fruit and in the beverages already referred to. In the

[1] Report of Departmental Committee.

case of jams 2 grains per lb. (0·03 per cent.), and in that of beverages 7 grains a gallon (0·01 per cent.) are considered by some manufacturers to be sufficient for preventing fermentation,[1] though these quantities are frequently exceeded, as much as 108 grains a gallon having been found in lime juice, 140 grains a gallon in black-currant wine, 28 grains a gallon in beer, 37 grains a gallon in wine, and 8½ grains per lb. in jam.[2]

With regard to the effects exerted by salicylic acid on the digestive ferments, less attention has been paid than in the case of boric acid and formalin. *A priori*, taking into account its antiseptic and germicidal properties, it would be expected to have an inhibitory action in proportion to the strength in which it was used.

Lauder Brunton[3] states that the action of ptyalin is arrested by 1 in 1,250, pepsin by 1 in 250, and pancreatin by 1 in 9,000 parts of salicylic acid.

Williams and also Starling[4] have found that this effect is only exerted in an acid medium, so that, whilst gastric digestion should be retarded, that of the pancreatic juice would probably be unaffected.

Salicylic acid, or more usually its sodium salt, is frequently employed medicinally, and its pharmacological actions have been studied, the maximum single dose being 20 grains (reduced from 30 grains in 1898), whilst as much as 120 grains in the twenty-four hours is not infrequently given under careful supervision.

Unless well diluted it acts as an irritant to the stomach, causing pain and vomiting. It circulates in the blood as salicylate of soda, and is excreted chiefly by the urine, either in the form of salicyluric acid or salicylic acid, the sodium salt having been acted upon by glycin, or by the acid phosphates of the urine respectively.

On the heart it exerts a depressing effect, though this is

[1] Report of Departmental Committee. [2] *Ibid.*
[3] *Pharmacology and Therapeutics.*
[4] Report of Departmental Committee.

probably to some extent due to the impurities already mentioned as being present in the artificial variety.

Occasionally it acts as an irritant in its passage through the kidneys, producing albuminuria and even hæmaturia. Sometimes skin eruptions, erythemata or petechiæ, follow its administration.

It is one of the few drugs that appear to act as direct cholagogues, giving rise to an increased flow of bile.

It will thus be seen that salicylic acid is a powerful drug, and one which requires careful administration, and this is emphasised by the fact that it affords one of the best instances of the effects of personal idiosyncrasy in the production of toxic symptoms by the administration of a drug.

In a considerable proportion of persons—according to Hale White as much as 60 per cent.[1]—a train of symptoms known as 'Salicylism' occurs when the drug is given in pharmaceutical doses. Amongst these deafness, headache, delirium, vomiting, hæmorrhage in various parts of the body, failure of the heart, and death have been recorded. The dose necessary to produce salicylism cannot be definitely stated, since it will vary according to the age of the patient, the degree of idiosyncrasy, and the condition of the excretory apparatus.

Children generally take proportionate doses well, but great caution is necessary where the kidneys are the seat of disease, and also where heart disease is present. Stevenson[2] has cited the case of a physician in whom a dose of 10 grains would bring down the pulse rate by ten beats a minute.

The untoward results above described were much more frequent formerly than at present, and it has been proved that they were due to impurities contained in the salicylic acid. Since pure acid has been used they have rarely, if ever, been recorded. Kolbe took one gramme daily for nine months and continued in excellent health, and many other observers[3] have

[1] *Materia Medica.* [2] Report of Departmental Committee.
[3] *Food Preservatives.* R. G. Eccles, M.D., p. 49.

administered the acid in daily doses for considerable periods without producing any unfavourable symptom.

This acid is only used to a limited extent, and chiefly in liquids or foods containing saccharine matter. It is unlikely, therefore, to be consumed in any quantity or for any lengthened period, and if the amount does not exceed that which is really necessary for preventing fermentation, possibly no harmful results will follow. It is absurd, however, to suggest the same limit for all fluids, as has been done by the Departmental Committee, irrespective of the quantities which may be imbibed daily, of the conditions under which they may be stored, and of the length of time they are required to keep. Lager beer, for example, requires only to be kept for a comparatively short time and is always stored in a cool place, whereas British wines, fruit juices, and syrups are expected to keep indefinitely, whether in a cool cellar or in a shop window. The latter, therefore, must require more preservative than the former, and the larger quantity should be permissible seeing that such liquids are only used in small quantities at a time, whilst lager beer may be drunk by the pint many times daily. The declaration of its presence and amount would probably meet most of the objections that can reasonably be raised to its use.

Drs. McAlister and Bradshaw, in an article contributed to 'The Lancet' (March 14, 1903) on 'Salicylic Acid as a Food Preservative,' say that the acid is alleged to be injurious to health on three grounds: (1) that, being an antiseptic, it is liable to destroy the digestive ferments; (2) that after absorption it interferes with nutrition; and (3) that it is an irritant, and apt to injure the mucous membrane of the stomach and intestines. The authors contend that the first objection is refuted by the fact that a saturated solution of the acid (1 in 500) retards artificial gastric digestion of proteid matter only to the same extent as a solution of common salt of equal strength, and that an equivalent amount of sodium salicylate does not retard at all the digestion of starch by the pancreatic juice. With reference to the second objection, experiments

conducted by one of the authors upon himself and on some healthy children showed that no ill effects were produced. The adult took 5 grains daily, the children less in proportion to age and weight, the experiments extending over one month. They suggest that previously recorded experiments made with cats were not conclusive, as the cats probably refused the food owing to its disagreeable taste, and consequently suffered loss of weight from this cause. The third objection they meet by arguing that pure salicylic acid is certainly not more harmful to epithelium than pure hydrochloric acid, and that the latter acid diluted to the same extent (1 in 500), so as to correspond with the strongest aqueous solution of salicylic acid which can be administered, is a constituent of the normal gastric juice.

Finally the authors contend that, as temperance beverages must not only be made to keep when bottled, but also for a reasonable length of time after being opened, some antiseptic is necessary. If the use of such an antiseptic as salicylic acid is prohibited, manufacturers will be compelled to use artificial essences less prone to decomposition, but probably more objectionable than the antiseptic.

It has recently been contended that salicylic acid has a cumulative action, because it can be detected in the urine many hours after the last dose has been taken. Ringer[1] states that it is speedily eliminated, though a trace may remain for four days after discontinuance of the medicine. Bruce says,[2] on the other hand, that it is but slowly excreted in the sweat, saliva, bile and mucous secretions generally. Wood[3] says: 'Salicylic acid escapes from the body chiefly through the kidneys, its elimination beginning almost immediately after its ingestion, but its elimination proceeds slowly. Thus in a case of exstrophy of the bladder it was detected in the urine dripping from the ureters eight and a half minutes after ingestion, and it has been found in the urine eight days after the exhibition of the last dose.' No reference is made in any of these works to any cumulative action. Experiments made by one of us on

[1] Ringer and Sainsbury, *Therapeutics*.
[2] Bruce, *Therapeutics and Materia Medica*. [3] Wood's *Therapeutics*.

healthy adults indicate that the acid cannot usually be detected in the urine for more than twenty-four hours after the last dose of 5 or 10 grains of sodium salicylate. With the larger dose on one occasion the acid was detected after thirty hours but had disappeared at the expiration of thirty-six hours. After taking doses of 5 and 10 grains daily for a week, the acid had disappeared in 30 hours in all cases.

The acid is most frequently found in Lime Juice preparations and especially in the Cordial; in fact, it is difficult to obtain a sample free from it, though in a few cases sulphurous acid is used instead. In such cordials the amount present varies from 4 to 8 grains per pint, and a drinker of this temperance beverage would have to take a large quantity to imbibe 5 grains of salicylic acid. The citric acid would be much more likely to disturb his digestive organs than the salicylic acid, and in any case the latter would be eliminated from the system with sufficient rapidity to prevent any cumulative effects. Most probably the diuretic effect of the citrates would assist in the elimination.

There is apparently no evidence that salicylic acid employed as a preservative has ever produced any injurious effects, though Dixon Mann, in his evidence before the Departmental Committee, mentioned a case in which the consumption of cider, into which the acid had been introduced, appeared to cause looseness of the bowels. It is obvious, however, that if the acid does occasionally produce symptoms of gastro-intestinal irritation, such symptoms are induced by so many and varied agencies that it would be practically impossible in most cases to trace the effect to the preservative.

The United States Treasury have requested that their Consuls in France may be instructed to refuse the authentication of invoices of fruits preserved by the introduction of salicylic or benzoic acid, as they consider food so treated to be injurious to health. Dr. Eccles[1] strongly protests against the action of the Treasury, affirming that that Department cannot adduce a single instance of harm resulting from the use of

[1] Eccles, *Food Preservatives*.

salicylic acid in preserved food, and Professor Ingram,[1] after examining the organs and tissues of animals fed on such food, declares that there is no injurious effect on any internal organ.

(2) *Benzoic Acid*

This acid is widely distributed in nature, being found in such resinous products as benzoin, balsam of Tolu, storax, and dragon's blood; in essential oils, in cinnamon, bergamot, calamus root, cloves, &c.

The acid or its sodium salt is occasionally used as a preservative, chiefly for the same classes of foods for which salicylic acid is employed. Thus it has been found in wines of low alcoholic strength, in medicated and sacramental wines, in fruit juices, jams, jellies, and ketchup, in ham, bacon, potted meat, minced meat and sausages. In France, when salicylic acid was prohibited, benzoic acid was to some extent substituted, and this may possibly be the case in other countries.

It has been long known as an antiseptic in surgery. The old remedy Friar's balsam owes its antiseptic action to the presence of this acid, and has been a favourite application to wounds for centuries. It is probably quite as powerful an antiseptic as salicylic acid, but, no one having any special patent for its manufacture, there has been no inducement for manufacturers to advertise its properties. Wernitz found that it arrested the action of enzymes in aqueous solutions, and the following table, showing the strength necessary to effect this and comparing it with salicylic acid, is taken from Brunton's 'Pharmacology':

—	Diastase	Invertin	Ptyalin
Salicylic acid .	1 in 5,100	1 in 166	1 in 1,250
Benzoic acid .	1 „ 1,025	1 „ 400	1 „ 2,600

—	Pepsin	Pancreatin	Rennet
Salicylic acid .	1 in 250	1 in 9,000	1 in 200
Benzoic acid .	1 „ 200	1 „ 2,600	1 „ 300

[1] Eccles, *Food Preservatives*, p. 15.

Brunton, quoting Croix and Koch, also gives the results of experiments showing that with meat infusions benzoic acid is more powerful than salicylic acid.

—	Prevents development of bacteria in meat infusion	Kills developed spores	Prevents development of spores in unboiled meat infusion
Salicylic acid .	1 in 1,003	1 in 60	1 in 1,121
Benzoic acid .	1 ,, 2,867	1 ,, 410	1 ,, 1,439

With anthrax spores different results were obtained by Koch, salicylic acid being the more powerful.

In medicine the acid is used as a stimulating expectorant, and for disinfecting the urinary passages. Whether exhibited in the free state, or as the sodium or ammonium salt, it is absorbed by the blood and excreted in the form of hippuric acid, the urine acquiring an acid reaction and on occasions being somewhat irritating. A little is excreted from the lungs and possibly the skin. In medicinal doses (10 to 15 grains) it does not appear to produce any toxic effect, and no evidence of a cumulative action is forthcoming, though both of these would presumably occur in persons whose excretory functions are inactive, and possibly where idiosyncrasy exists.

Hutchinson stated before the Departmental Committee that he had experienced irritating effects locally after taking 5 to 10 grains of the acid on an empty stomach. This, however, has no bearing upon its use in very small quantities as a preservative. The arguments for and against its use are precisely the same as those given in the previous section in relation to salicylic acid. Of the two, it seems very probable, judging from medical experience, that there are fewer objections to the use of benzoic acid than to salicylic acid, and as it is much more difficult to detect and estimate, it is probable that in the course of time it will be much more generally employed; in fact there are reasons for believing that it is at present more extensively introduced than is usually supposed, and that its presence is overlooked.

CHAPTER VII

CHEMICAL PRESERVATIVES (*continued*)

Fluorine Compounds, &c.

Fluorine Compounds.—Certain compounds of fluorine are found to possess marked antiseptic properties, and they are used to a small extent for preserving butter, cream, and beer. An attempt has recently been made to introduce them into this country for use in the manufacture of jams and other foods, but as yet the attempt has either been unsuccessful, or analysts have failed to detect their presence. Hydrofluoric acid and fluoboric acid are probably the most powerful of the fluorine antiseptics. Richmond[1] has shown that when the former is added to fresh milk in the proportion of 0·5 per cent. the sample remains sweet for a period of some months. This is, of course, a much larger quantity than would be required to keep milk for ordinary consumption.

In the case of fluoboric acid the same observer found that 0·02 to 0·03 per cent. had an appreciable effect, and he estimated that it was at least five times more powerful as an antiseptic than boric acid. He also experimented with sodium fluosilicate, but found it too insoluble to be useful as a preservative, yet 'Salufer,' a solution containing 0·6 per cent. of this salt, is said to have a greater antiseptic effect than a 1 per cent. solution of mercuric chloride.

Hydrofluoric acid is too powerful a drug to be added to food-stuffs, and the same applies to its simple salts. The solution of the acid used in medicine contains only 0.16 per cent. of the pure acid, yet doses of 15 minims of this

[1] Report of Departmental Committee. Appendix, No. XXXII.

exceedingly dilute solution are said to often cause headache, nausea, and vomiting. Ammonium fluoride also causes gastro-intestinal irritation, a lowering of the blood-pressure, and slowing of the heart's action. The dose is 5 minims of a 1 per cent. solution, and this may give rise to unpleasant symptoms.

Some years ago one of us was consulted with reference to the suitability of fluorine compounds for preserving dairy produce, as it was stated that butter was being imported which contained these bodies, and in 1902 Hehner[1] pointed out that certain samples of Brittany butter contained fluorides, and stated that he had detected fluorine in twenty samples. The maximum amount met with was 4 grains to the pound, and he points out that a person using such butter might easily consume half a grain of sodium fluoride per diem. As the result of his experiments he concludes that 0·04 per cent. of sodium fluoride prevents salivary action, and that 0·02 per cent. greatly interferes with peptic digestion. From these experimental results, and the consideration of a quotation from the American Dispensatory given below, he concludes that 'the quantities of fluorides that are used as butter preservatives are not without injurious action upon the living body.' The following is the quotation referred to: 'Waddell states that the alkaline fluorides are not pronounced irritants, but when taken internally in doses of a grain to a grain and a half continuously they reduce the force and frequency of the pulse, at the same time depressing the temperature and increasing somewhat the flow of urine, without distinctly affecting either the respiratory or the cutaneous functions. This accords with the physiological studies of Tappeneiner, who found in animals the soda salt to powerfully depress blood-pressure by acting on the vaso-motor centres. Death after profound collapse was produced by centric failure of respiration. Dr. Waddell also affirms that there is an enormous decrease in the number of red corpuscles, which he believes, but does not prove, to be the

[1] *The Analyst*, June 1902.

result of a direct action upon the spleen.' The action of boro-fluorides and silico-fluorides does not appear to have been studied, but from what has been said it is obvious that there can be no justification for the introduction of fluorine compounds as preservatives. Even if certain of them are five times more powerful as antiseptics than boric acid, they have so much greater an effect upon the human system that the latter (boric acid) must be infinitely preferable as a preservative. In any case the onus of showing that the fluorides are harmless in the quantities used should rest upon the person using them.

Ammonium and sodium fluorides occur in certain preservatives sold in America for use in beer, and it is possible that they are employed to some extent in England, but, probably, no analyst in this country systematically examines foods for fluorides.

Alum.—This substance is not generally considered to be an antiseptic, but it is a constituent of certain preservatives sold for curing hams. An American ham preserver was found to contain 70 per cent. of potash alum and 21 per cent. of saltpetre.[1] It is also used to harden vegetables for pickling, and in baking powder to improve the appearance of the bread.

It is not a desirable addition to food-stuffs, although it may be difficult to prove that any harm results from its use in minute quantities. The medicinal dose is 5 to 10 grains, but it is rarely administered internally. In larger doses it may cause constipation or gastro-intestinal irritation. Apparently it is not absorbed by the blood.

Ammonium Acetate.—This salt is used occasionally for preserving meat. The flesh is dipped into a strong solution and then allowed to dry, when it is said to keep well for a considerable period. The ammonium salt disappears on roasting or boiling.

Copper Sulphate.—Salts of copper are probably used more for colouring purposes than for preserving. The copper

[1] Report of Departmental Committee

forms with certain proteids a compound possessing a dark green colour, hence the use of copper salts for colouring preserved peas, French beans, and other vegetables. The statement that copper merely preserves the natural colour of these vegetables is entirely without foundation, since chlorophyll after treatment with copper sulphate has its green colour destroyed when boiled with water, whereas vegetables which have been similarly treated retain their green colour in boiling water. The copper salt also hardens the exterior covering of peas, so that when preserved in bottles or tins the peas remain intact and the surrounding fluid clear. The integument of peas not treated with copper easily disintegrates, and the fluid becomes turbid. When this occurs the peas may be condemned as unsound, whereas they are perfectly good and wholesome. The subject will be further referred to in the section treating of colouring matters.

Sodium Carbonate and Lime.—These substances are sometimes added to milk and cream. They do not act as preservatives in the quantity employed, but, by combining with the acid products of fermentation, they delay the souring which is the popular index of fitness or unfitness for use. For this reason their use is strongly to be deprecated. A saccharine solution of lime is sold under a fancy name for the above purpose. Both are harmless in themselves in the quantities used.

Sulphuric Acid.—This mineral acid is occasionally added in small quantities to inferior vinegars, to prevent fermentative change. Its addition is totally unnecessary, but in the quantity usually employed it cannot be said to have any deleterious effect upon the consumers.

CHAPTER VIII

CHEMICAL PRESERVATIVES (*concluded*)

Formic Acid.—A 60 per cent. solution of this acid has recently been introduced into this country as a preservative, more especially for liquids prone to fermentation. It is closely allied to acetic acid, but has usually been considered inferior thereto as an antiseptic. This is probably a mistake, as a research at the Pasteur Institute showed that as little as 0·014 per cent. of the acid retarded the action of yeast, and that 0·08 per cent. entirely prevented fermentation. Roscoe, quoting Iodin,[1] says, 'Formic acid is a powerful antiseptic, preventing fermentation, putrefaction, &c., even more powerfully than phenol does.'

It occurs in the common nettle, pine needles, tamarinds, lemons, limes, and grapes. In raisins it is met with in larger proportions than in grapes, and very possibly it would be found in many more fruits were it carefully sought for. It is probably produced in small quantities in all fermentative changes, resulting in the formation of acetic acid. It is formed in the alimentary canal by the action of putrefactive organisms on fat, and its presence has been detected in the spleen, pancreas, thymus gland, muscle, brain, milk, sweat, and urine. In leucocythæmia it has been detected also in the blood and bone-marrow. It is contained in quantity in the bodies of certain ants, hence its name, and these animals are eaten as a delicacy by the aborigines of Australia.

It is evidently, therefore, widely distributed in nature, but it has found little use in medicine. Recently, how-

[1] Iodin. *Compt. Rend.*, lxi. 1179.

ever, Clement and also Huchard have recommended its use as a tonic. Clement's[1] observations show that formic acid is a powerful stimulant of muscular action, and in its tonic effects is closely allied to kola, cocoa, and caffein. Administered internally it dispels the sensation of general lassitude. Experiments controlled by the dynamometer and ergograph show that the muscular power undergoes a marked elevation within two days of the commencement of the treatment, whilst the amount of bodily exertion which can be undertaken without fatigue is increased. The dose administered was 8 to 10 drops, four times daily, of a 25 per cent. solution diluted with aerated water. Subcutaneously administered, it has been found useful in lupus and in chronic inflammation of the kidneys. Clement, however, found that even small doses long continued tended to produce irritation of the stomach, and this may militate against its use as a preservative, if his results are confirmed. Eight drops of a 25 per cent. solution contain 2 grains of the pure acid. Assuming that 0·1 per cent. were used for preservative purposes, a person taking about 2 ounces of fluid would receive this dose. Obviously, therefore, in many articles of food and drink it would be easy to exceed this quantity, and in beverages especially the dose might be frequently repeated. Its use, therefore, may not be entirely free from objection, but most probably its great dilution would prevent any irritant action.

Alcohol.—This liquid when diluted possesses comparatively feeble antiseptic properties; even when 'absolute' an exposure of one hour or more is required to destroy non-spore-bearing bacilli. The presence of a certain quantity, however, tends to check fermentation, the amount necessary for this purpose depending upon the nature of the fluid. Probably not less than 5 per cent. will prevent change in 'still' liquors, though less may suffice in beverages charged with carbonic acid gas. In British wines a deficiency in alcoholic strength indicates defective keeping qualities, and to remedy this salicylic acid

[1] *Presse médicale*, 1903, No. 67, p. 601.

or other preservatives are often used. Whether the special preservative or the alcohol is the more harmful may be open to discussion.

Foreign wines containing a large quantity of fermentable sugar, such as port and sherry, are fortified by the addition of alcohol, but this aspect of the case is of more interest to the officers of the Inland Revenue than to the physician.

Strong spirits are used for certain preserving purposes. Housewives, for instance, generally soak the tissue paper, which they lay upon the exposed surfaces of jams before tying over, in brandy to prevent the growth of moulds, and probably the addition of rum to mince-meat has a preservative action. In Ceylon arrack is added to curried meat to improve its keeping properties.

Saccharin.—This substance may be mentioned in connection with wines and sweet beverages, inasmuch as it is used to replace sugar, and so reduce the tendency to fermentation. It is added to ciders and beers in the proportion of one-eighth to one-half an ounce per 100 gallons. It is affirmed that its addition disguises inferior qualities or liquors already showing signs of taint. A number of similar substances derived from coal-tar have recently been introduced, and there is reason to believe that they affect the digestive functions. Dr. Plugge 'has shown that the addition of saccharin in artificial digestive experiments with various digestive ferments interfered with the breaking up of food substances. Dulcin, another sweetening body, which has been used as a substitute for saccharin, was given to a dog at the rate of 1 gramme a day. The animal died in three weeks (Aldehoff).'[1]

Vinegar is a very popular condiment and preservative. Taken in excessive quantities it interferes with the digestive processes, and its use in such quantities, if persisted in, ultimately causes emaciation. Used in moderation, however, it is not likely to produce injurious consequences; nevertheless, if it were not one of the oldest preservatives in use,

[1] *British Medical Journal*, May 10, 1902.

objections would be raised to its introduction. The effect of excessive quantities on adults and children, and its potential effect on invalids, would be dilated upon, and its use probably condemned.

Peroxide of Hydrogen.—During recent years processes have been devised for preparing this powerful oxidizing agent at a cheap rate, and it has been proposed to utilize it for the preservation of certain articles of drink, such as milk and beer. It readily parts with a portion of its oxygen, especially at a temperature of about 50° C., splitting up into oxygen and water. The oxygen liberated in the nascent condition appears to exercise a germicidal effect, and as only a little water is thus added to the liquid no trace of antiseptic remains. Tangott, as the result of a long series of experiments, concluded that the pure peroxide is twice as strong a germicide as carbolic acid, and Schillow finds a 0·5 per cent. solution kills the cholera spirillum in three minutes, and a 0·3 per cent. solution in an hour. The typhoid bacillus, however, proved far more resistent, requiring a 1·1 per cent. solution to kill in three minutes, and a 2 per cent. solution to kill in one hour. Schillow also found that the peroxide solution was several times more powerful if used at 38° C. than at 18° to 20° C. Dr. Budde, of Copenhagen, has recently patented the use of this article for sterilizing milk and other fluids at 50° C., and Dr. Lewin and others have conducted investigations to ascertain the effect upon milk when used as Budde directs. Lewin added to milk the typhoid bacillus, diphtheria bacillus, tubercle bacillus, spore-bearing bacilli of anthrax and from hay, respectively, and submitted the mixtures to the influence of varying quantities of the peroxide for varying times. He arrived at the conclusion that 'three hours' heating of the milk at 50° C., when the right proportion of hydric peroxide has been added, is quite sufficient to obtain a well-preserved milk, free from all spores and bacteria, pathogenic or non-pathogenic.' Milk so treated is unchanged in appearance and taste, but it is admitted that the enzymes present in the milk are affected, and it is probable

that it is by the interaction of the peroxide and the enzymes that the nascent oxygen is produced. How far this change will affect the nutritive quality of the milk remains to be seen, but physicians in Denmark, Norway, and Sweden have reported most favourably upon it. The treatment above referred to is now known as the 'Buddeizing' process, and liquids so treated are said to be 'Buddeized.'[1] The liquor hydrogenii peroxidi of the British Pharmacopœia contains 3 per cent. of H_2O_2, or ten volumes of available oxygen. Solutions much stronger than this are now prepared. The dose is one-half to 2 drachms (1·8 to 7 c.c.). The solution is more frequently used as a spray, gargle, or dressing. It decomposes so readily when mixed with organic substances that the whole more or less rapidly disappears. It is very unlikely, therefore, that it will ever be used in such quantities for preservative purposes as to have any injurious effect upon persons using liquids to which it has been added.

Asaprol, or Abrastol.—The substance sold under these names is a calcium salt of β-naphthol-sulphonic acid. It is a white powder, freely soluble in water, and it is claimed that it has antiseptic properties equal, if not superior, to salicylic acid. We are not aware of its presence having yet been detected in any article of food or drink, but there is very little doubt that it is being used. In medicine it has been recommended for use as an antipyretic in place of salicylic acid, in doses of 10 to 30 grains. Should this substance be found in any article of food or drink, it would probably rest with the person who had added it to prove that it was innocuous in the quantity employed. The use of new chemicals should not be permitted until extended series of experiments have been made to demonstrate their suitability for the purpose of food preservation.

[1] Whilst these pages were going through the press an article has appeared in *The Lancet*, January 27, 1906, by Professor Hewlett, in which he records experiments confirming Lewin's results, and expresses the opinion that the process 'has a great future before it.'

Crude Pyroligneous Acid.—This is the crude acid obtained by the destructive distillation of wood, and containing large traces of creosote and other tarry matters capable of imparting to fish and flesh the odour and taste of smoked products. Such food stuffs may be effectually preserved by immersion for a period in this acid and after drying they are sold as 'smoked.' The time occupied in the process is much shorter than that of 'smoking' and the whole process is more under control. There is no doubt that the antiseptic principle in both cases is creosote, an acknowledged poison. How far the use of such a powerful drug is permissible in the preservation of food stuffs may be a debatable question, but as 'smoking' is an ancient mode of preservation the point is never raised. Had it been a recent introduction there can be no doubt that it would have been received with a howl of execration, and the evidence adduced of the poisonous nature of the antiseptic would have sufficed to put an end to the practice speedily. According to Brunton[1] 'Creosote destroys low vegetable organisms, and prevents the fermentation which they cause. When administered to small animals it causes great dyspnœa, weakening of the heart's action, paralysis and often sudden death.' It destroys the epithelium, and large doses cause nausea, vomiting, colicky pains and diarrhœa. In doses of 1 to 5 minims it is used for phthisis and to check sickness.

[1] *Pharmacology, Therapeutics and Materia Medica.*

PART II

CHAPTER IX

MILK

HAVING discussed the chief methods by which the preservation of various foods is effected, we propose to deal with the question of the necessity and desirability of these processes as looked at from a public health point of view, and for this purpose it will be convenient to consider separately each of the principal foods which are subjected to preservative processes.

Milk is perhaps the most important food in this connection, since, while it enters largely into the diet of most persons, it is the chief or only nutriment for infants, young children, and invalids, who together form an appreciable proportion of the community.

As it contains all the elements of food it forms an excellent culture medium for nearly all kinds of bacteria, pathogenic and otherwise, many of which, in addition to any direct injurious influence on the human economy, are capable of decomposing some of the milk constituents, with the formation of products which may or may not be deleterious to the health of the consumer.

Milk as it leaves the glands of a healthy cow is sterile, and can be collected in this condition if elaborate precautions are taken, but the opportunities for the introduction and subsequent multiplication of micro-organisms are so great, that by the time it reaches the distant consumer it seldom contains under 1,000,000 bacteria per cubic centimetre (16,400,000 per cubic inch), and may contain 10,000,000 to 15,000,000 per cubic centimetre. In one sample which was taken in the

month of February, we counted 16,600,000 organisms per cubic centimetre, notwithstanding the fact that the milk contained about 90 grains of boric acid per gallon. There had, however, been an interval of fully 48 hours between milking and the examination, and the milk was turning sour.

The greatest degree of pollution probably takes place at the time of milking, which is not surprising when one considers the dirty state of the udders and flanks of the cow, the polluted air of the byre, and the condition of the hands and clothes of the milker, in many farms where no especial precautions are taken.

Professor Russell[1] recounts some experiments carried out by him illustrating the possibilities of pollution by neglect of simple cleanliness: 'A cow that had been pastured in a meadow was taken for the experiment, and the milking done out of doors, to eliminate as much as possible the influence of the germs in the barn air. Without any special precautions being taken, the cow was partially milked, and during the operation a covered glass dish, containing a thin layer of sterilised gelatine, was exposed for sixty seconds underneath the belly of the cow in close proximity to the milk-pail. The udder, flank, and legs of the cow were then thoroughly cleaned with water, the milker's hands washed first with corrosive sublimate, and afterwards with pure water, and the milking resumed. A second plate was then exposed in the same place for an equal length of time, a control also being exposed at the same time at a distance of 10 feet from the animal and 6 feet from the ground, to ascertain the germ contents of the surrounding air. From this experiment the following instructive data were gathered. When the animal was milked without any special precautions being taken, there were 3,250 bacterial germs per minute deposited on an area equal to the exposed top of a 10-inch milk pail. After the cow had received the precautionary treatment suggested above, there were only 115 germs per minute deposited on the same area. In the plate that was

[1] *Dairy Bacteriology*, p. 46.

exposed to the surrounding air at some distance from the cow there were sixty-five bacteria. This indicates that a large number of organisms from the dry coat of the animal can be kept out of the milk if such simple precautions as these are carried out.'

Had the milking been performed inside the byre, the pollution would undoubtedly have been much greater. Under ordinary circumstances it is difficult to produce a milk containing less than 50,000 bacteria per cubic centimetre. With extraordinary precautions the milk may still contain over 2,000 per cubic centimetre.

Further contamination may arise from dirty utensils and milk cans, and exposure of the milk during transit and storing, while, at a favourable temperature, multiplication will rapidly take place, even though the initial number of organisms be small.

Bacteria may also be introduced when the milk ducts are the seat of inflammation (mastitis), the fore-milk being especially affected, and likewise by the addition of water for purposes of adulteration.

It will be gathered from these remarks, and also from the section dealing with the preservation of milk by refrigeration, that in warm weather it is impossible to supply good milk to consumers at a distance without taking some means to check the introduction and growth of these organisms.

The methods chiefly employed are sterilization, pasteurization, refrigeration, and the addition of antiseptics.

We propose to deal first with the addition of antiseptics, since this has been largely practised, is the easiest method for the milk dealer, and has given rise to great differences of opinion among medical men, chemists, and those connected with the milk trade.

The commonest antiseptics in use are boric acid or borax, and formaldehyde, whilst salt, saltpetre, salicylic acid, the fluorides, and sodium carbonate are occasionally employed.

The extent to which these chemical substances are added varies considerably, not only in the different seasons of the year

but also in different parts of England. It is probably largely influenced by the energy or the reverse shown by the local authority in taking action in this matter.

Some indication of the prevalence of preservatives in milk is furnished by the returns of public analysts who have systematically searched for these substances, though their figures, based as they are on a comparatively small proportion of the total milk supply, must necessarily be accepted with a certain amount of reserve.

The following figures, taken from the Report of the Departmental Committee, show the number of samples of milk examined for preservatives in different parts of the kingdom:

Locality	Authority	Total samples	Preservatives: Boron compounds	Preservatives: Formaldehyde	Total containing preservative	Percentage preservatized
Various . . .	Government Laboratory	296	48	7	54 [1]	18·2
Birmingham . .	Dr. Hill	1,537	–	-	135	8·9
Glamorganshire .	Mr. W. C. Williams	976	17		17	1·7
Liverpool. . .	,, ,,	862	12	6	18	2·1
County of Lancaster [2]	,, ,,	253	2	–	- -	2·2
County of Lancaster	,, ,,	489	—	7		

In Cardiff 8·5 per cent. of the samples of milk taken in 1898 were reported as containing boric acid, and the percentage rose to 13·5 at a later date.

The above figures refer to samples of milk examined regularly throughout the year. In the summer the percentage preservatized rises considerably. Thus Dr. Muter found that during the months of September to December 1899 the percentages were 41, 29, 18, and 13 respectively.[3]

During the latter half of September and the first half of October 1901, out of 49 samples of milk taken in Leeds, preservatives were found in 25, a percentage of 51.[4]

[1] One sample contained both formalin and boric acid.

[2] Two hundred and thirty-six further samples (489 in all) were only examined for formalin, and, supposing the proportion to be maintained, the total samples preservatized with boric acid or formalin would be 11, or 2·2 per cent.

[3] Report of Departmental Committee. [4] *Ibid*

In Birmingham, from April 1896 to September 1900, 1,877 samples were examined.[1] During the six months November to April the percentage containing preservative was 4, whilst it rose during May to October to 16.

Similarly a variation is seen between Sunday and weekday samples. In the Government Laboratory the percentage in the former case was found to be 28·9 as against 14·2 in the latter.

When successful prosecutions have been obtained against milk dealers, on account of the addition of boric acid, formalin is frequently substituted. In Birmingham, for instance, when convictions were obtained in 1897 and 1898, the number of samples containing boric acid decreased, whilst those containing formaldehyde increased:[2]

Year	Percentage of sample containing		
	Boric acid	Formaldehyde	Both
1896 (April to Dec.)	8·3	-	-
1897 . . .	5·5	3·3	0·0
1898 . . .	3·1	6·7	0·4
1899 (Jan. to Sept.)	1·2	6·3	0·0

No figures are available as to the proportion of samples which contain salicylic acid, saltpetre, or the fluorides. Until lately it has not been the general custom of analysts to make a routine search for preservatives, and even when this is done attention is chiefly paid to boron compounds and formalin.

Milk offers exceptional opportunities for the repeated introduction of antiseptics by different individuals between the time of milking and its consumption, and it is therefore not surprising that the quantities which have been found by different observers vary enormously. This may possibly be due to the difficulty which undoubtedly exists in making an accurate quantitative determination, but the figures show variations too wide to be explained in this way. In the case of formaldehyde there is no recognized method by which

[1] Report of Departmental Committee. [2] *Ibid.*

the amount which may have been added can be ascertained, and the fact that a definite compound appears to be formed between this substance and proteids adds to the difficulty.

The following table, taken from the Report of the Departmental Committee, shows the maximum and minimum quantities of boric acid which have been found by different observers:

Authority	Amount of boric acid in grains per pint	
	Maximum	Minimum
Professor A. W. Blyth	80·0	–
Dr. W. Williams	26·2	1·7
Dr. J. R. Kaye	20·0	—
Mr. W. F. Lowe	20·0	6·0
Professor Thorpe	17·5	—
Dr. A. Hill	15·7	0·625
Mr. C. E. Cassal	12·6	2·4
Dr. E. Walford	9·2	0·35
Dr. J. S. Cameron	2·5	—

Although these figures show considerable variations, the differences are, with the exception of Dr. Blyth's case, not so much greater than those in the quantities of boron preservatives recommended by the manufacturers of these preparations. According to a list drawn up by Professor Thorpe in the appendix to the Report of the Departmental Committee, these amounts vary from 1·2 to 14 grains of boric acid per pint, whilst in the case of 'Burton's Household Milk and Food Preservative,' which is described as 'harmless and effectual,' and appears to consist solely of boric acid, it is recommended that 'for small consumers a teaspoonful will be sufficient for a quart of milk.'[1] If these directions were followed, the milk would contain about 45 grains of boric acid per pint.

A large number of dairymen furnished the Departmental Committee with a statement of the quantities of boric acid or patent preparations which they were in the habit of adding

[1] Report of Departmental Committee.

to milk. These generally varied from 1 to $2\frac{1}{2}$ ounces in 17 or 18 gallons, which is equivalent to about 3 to 8 grains per pint.

According to Mr. Brierley,[1] the ordinary practice in the neighbourhood of the borough of Southamption is to take a pound of boron preparation, dissolve it in 1 gallon of water, and add a pint of the solution to 8 gallons of milk. This would be equivalent to about $12\frac{1}{2}$ grains a pint.

The quantity of formaldehyde which is added to milk is, as has already been indicated, a difficult matter to determine, since it somewhat rapidly decomposes in the presence of organic matter. The amount recommended, however, by the manufacturers of trade preparations varies from 1 part of formaldehyde[2] in 32,000 to 1 in 120,000.

It is quite possible that this proportion may be exceeded, and one dairyman, in reply to a request for information, stated that he was in the habit of adding 1 gill of Schering's formalin solution to 17 imperial gallons of milk, during the three or four hot months of the year. This is equivalent to 1 part of formic aldehyde in 780 of milk. Others employed a proportion of 1 in 20,000.

With so strong a solution (formalin contains 40 per cent. of formic aldehyde) a small error in the measurement of the antiseptic will make a considerable difference in the proportion which it bears to the milk.

As regards saltpetre, this is occasionally added alone in about the proportion of 3 grains per pint of milk, but it will sometimes be present in smaller amounts, often in conjunction with common salt, as a constituent of some preparation consisting chiefly of boron compounds.

In order to arrive at a conclusion as to whether or not the addition of chemical preservatives to an article of food should be permitted or prohibited in the interests of the public, it is necessary to consider the two following questions: first, whether the presence of these chemical compounds, in the

[1] Report of Departmental Committee. [2] *Ibid.*

proportions necessary for preservation, is likely to be attended with injury to health; and secondly, whether the trade of the country can be carried on without such additions. If the first question can be answered in the affirmative, the case for the total prohibition of preservatives is clear, whilst if in the negative, the second consideration becomes of importance, involving, as will be shown later, in the case of butter and dairy products the interests of the large export trade of various countries, including Ireland and the Colonies.

A further point which must be considered is the possibility or otherwise of limiting by legislation the quantity and kind of preservative which may be permissible in different species of food, supposing total prohibition to be undesirable.

As regards the addition of boron compounds to milk it will be remembered that, according to various observers, the smallest quantity of antiseptic which is of any service for the preservation of milk is about 4½ grains per pint, and that this proportion delays the souring process for only a few hours in hot weather, whilst many times this amount has been found on occasions. Now a considerable portion of the population of England, consisting of hand-fed infants, and persons suffering from various illnesses, notably typhoid fever, rheumatic fever, and acute and sub-acute nephritis (inflammation of the kidneys), lives almost exclusively on milk, whilst the same food enters very largely into the dietary of older children, and those who are the subject of the different fevers, gastric ulcer, gastritis, chronic Bright's disease, and other conditions too numerous to mention. Milk is, in fact, *par excellence*, the food for infants, children, and invalids.

The volume of undiluted milk which should be taken *per diem* apart from any other food varies from about 5 pints in the case of an adult to 3 ounces in that of a new-born child. If we accept 4½ grains as being the minimum quantity of boric acid necessary to preserve a pint of milk, the adult will take a little over 20 grains, and the baby about two-fifths of a grain, a

day; in the former case the pharmacopœial dose will not be reached, in the latter it would probably be exceeded.

A child of four months takes about 15 ounces of milk (exclusive of water added for purposes of dilution), and this would contain a little over 3 grains of boric acid, the suitable medicinal dose at this age being about 2 grains.

It will thus be seen that in an exclusive milk diet a quantity of boric acid nearly equal to or exceeding the full medicinal dose authorized by the British Pharmacopœia will be introduced, even supposing that no more than 4½ grains is added per pint, and that this administration will proceed for a considerable period of time.

Some grounds for doubting whether this amount is sufficient to retard all the fermentative changes which take place in milk have been mentioned, and the analyses quoted show that in practice it is frequently exceeded.

Dr. Wiley's investigations, and the other experiments to which we have referred, indicate the probability that moderate quantities of boric acid may interfere with the digestive processes or the assimilation of food even in healthy individuals, and we have given instances showing that ordinary medicinal doses occasionally produce toxic effects in such persons; but it is in regard to departure from normal health that the subject assumes the greatest importance. Boric acid should only be administered, if at all, under the most careful supervision to people suffering from kidney disease or digestive troubles, occasions on which a milk diet is especially indicated, and Dr. Harrington's experiments, to which we have referred, should be remembered in connection with the former condition. Moreover, acute nephritis is not an uncommon complication of scarlet fever, and boracized milk may therefore be a source of danger in such cases, whilst, as already mentioned (Chapter III.), boric acid should only be administered with great caution to pregnant women, some authorities alleging that the drug exerts a contractile effect on uterine muscle. Again, in typhoid fever, when milk usually forms almost the sole article of diet for six

or more weeks, it is of paramount importance that the digestive functions should not be interfered with in the slightest degree, and it is impossible to guarantee that such shall not be the case when boric acid or borax are added to the extent which actually occurs. It must be admitted, however, that typhoid patients are often treated with powerful disinfectants, which must necessarily interfere with the various processes of digestion, and that such patients are said to be greatly benefited by the treatment, but when this is the case the antiseptic is administered in known doses and under careful supervision.

Annett's experiments with kittens certainly suggest strongly that boric acid may act unfavourably on the nutrition of the very young, and though confirmatory evidence is wanting, his results have not yet been disproved.

So large a proportion of the general population is included in the above category, that one is driven to the conclusion that boric acid, in the proportion necessary to 'preserve' milk, is an undesirable constituent, and that its addition may be associated with considerable danger to health. The further objection, common to all preservatives, that their use permits of an 'unclean' milk being regarded as 'clean,' will be referred to later.

In the case of formic aldehyde, beyond the suggestive epidemic at the Hendon Asylum referred to in Chapter IV., no direct evidence is forthcoming to show that injury has been caused by its use as a preservative, though the effects experienced by Hehner after the self-administration of 1 in 12,500 formaldehyde have already been quoted.

According to Rideal and Foulerton 1 part in 50,000 is sufficient for the preservation of milk, but we have seen that this amount is frequently exceeded. By a reference to the chapters dealing systematically with the chemical preservatives, it will be observed that the digestive ferments are inhibited in proportion to the strength of the antiseptic, and that a definite compound is formed with the proteid molecule, whereby its digestibility

may be impaired. Hence it is obvious that unless it be possible strictly to limit the quantity of formic aldehyde, there is every chance that the nutrition of those who have to depend solely on milk as a food will be retarded, with a consequent danger to health. Annett's experiments on kittens, and Tunnicliffe and Rosenheim's observations on a delicate child suggest that this may be the case.

Unfortunately there is no accurate method of determining the amount of formaldehyde originally added to milk, and so many opportunities arise for the repeated addition of a preservative that a definite limit would be almost impossible to enforce.

We must therefore agree with the conclusion of the members of the Departmental Committee, that formic aldehyde should not be used as a preservative for milk.

Salicylic acid is seldom employed alone for the preservation of milk, and does not seem to be well adapted for this purpose, but is occasionally contained in small quantities in mixtures consisting chiefly of boron compounds.

The same objections to its use in milk hold good as with boric acid. The marked idiosyncrasy which exists amongst a proportion of the population in the case of this drug has been already referred to, and is an additional reason for objecting to its use in milk.

Saltpetre, curiously enough, received very little attention at the inquiry of the Departmental Committee. The effects of this salt on the digestive ferments, on the gastro-intestinal mucous membrane and on the kidneys, have been mentioned, and it appears to us that it is, at least, as undesirable an addition to milk as the boron compounds.

With regard to salt it is doubtful if a quantity short of that required to produce a saline flavour would be of any real service, and even this addition would probably be unattended with evil consequences.

The remaining preservatives, the fluorides, have not received much attention: such knowledge as we have of them

is distinctly unfavourable, and unless they can be shown to be harmless, they too should be dispensed with.

As regards sodium bicarbonate, we have already pointed out that its chief function is to neutralize the lactic acid produced by fermentation. In this way milk which is undergoing decomposition may be rendered palatable, and its real condition be masked. There is therefore no defence for such an addition.

It has been suggested by some that, instead of prohibiting the use of preservatives entirely in milk, these should be limited, and declaration made compulsory. It is extremely doubtful, however, when one considers the method in which milk is distributed, whether this would be possible. Moreover the average consumer is unlikely to be able to form a judgment as to the desirability or otherwise of purchasing milk to which an antiseptic has been added, and the labelling of a sample as 'preserved' might lead him to believe that it was a better article than ordinary milk.

Before leaving the subject it should be mentioned that many medical officers of health are of opinion that the addition of antiseptics to milk is one of the causes of infantile diarrhœa, and of the high mortality amongst infants under one year of age. It is a striking fact that although sanitation has made enormous strides in recent years, with a consequent progressive lowering of the general death rate, the infantile mortality (deaths of children under one year of age per 1,000 births) has increased. This is shown by the following figures (for all England) taken from the Registrar-General's reports, and grouped in five-yearly periods:

Five-yearly period	Number of deaths of infants under 1 year of age per 1,000 births	General death-rate per 1,000 living
1878-82	142	20·3
1883-87	143	19·4
1888-92	146	19·0
1893-97	152	17·8
1898-1902	152	17·4

Though suggestive, these figures by no means prove the causal relationship, since infantile mortality depends on many factors, involving among others the consideration of the employment of female labour, overcrowding, hand feeding, &c. It is always higher in towns than in the country, and there is a steady tendency towards the aggregation of the population in urban districts, with its natural consequences.

There is, however, another manner in which the use of preservatives in milk may influence the infantile mortality, apart from the presence of the antiseptics themselves, since it is possible that, by deferring the souring process, milk may be sold containing not only deleterious products of fermentation other than lactic acid, but also pathogenic organisms such as those of the B. coli type, capable of causing injurious effects on the infants consuming it. In other words, the milk may appear to be fresh and clean, yet be stale and unclean, and potentially dangerous, without the purchaser being aware of the fact.

This is a cogent argument against the use of preservatives, as, if their use is prohibited, it will be absolutely necessary for dairy farmers to maintain a very much higher standard of cleanliness in and around their cowsheds and in the actual milking processes than is often the case. At present the farmer who pays attention to matters of sanitation obtains no better price for his milk than one who, by the addition of preservatives, is able to partially neutralize the effects of the filthy state of his byres. The Cowsheds, Dairies, and Milkshops Order is practically a dead letter in many parts of rural England, but the prohibition of the use of chemical antiseptics in milk should go a long way towards securing the improvements which the Order has failed to effect.

From what has been said it will be gathered that preservatives added to milk are a source of danger to the health of a considerable proportion of the public, and we now propose to refer to our second inquiry, as to whether the milk trade of the country can be carried on without the use of preservatives.

That such is the case is proved by the fact that for some years the Aylesbury Dairy Company have been able to supply at least 100,000 persons a day in London with milk absolutely free from preservatives, although a portion of their supply comes from Wiltshire and even Cheshire, a distance of 200 miles. A few complaints are occasionally received as to the milk being sour on delivery (in 1899, out of 5,000,000 deliveries from the head office, 78 such complaints were made),[1] but there is no doubt that these could be prevented by the provision of better means of straining and cooling the milk at the farms and of keeping down the temperature during transit. Although the families supplied by this company are largely members of the well-to-do classes, a considerable trade is also done with those who buy the milk in quite small quantities. No doubt the same is true of many of the other large dairy companies.

It will be gathered also from the table showing the proportion of samples of milk found to contain preservatives that over 90 per cent. of the milk sold in Birmingham, and nearly 98 per cent. of that in Liverpool, is free from such addition. Of samples taken in the former town, in the six warmer months, 84 per cent. were free from preservatives. Mr. T. Carrington Smith[2] by straining and cooling his milk was for several years able to consign 100 gallons of unpreservatized milk a day to London from his farm in Mid-Staffordshire, a distance of 120 miles, with perfect success. His only difficulty occurred on Sundays on account of the absence of a morning train. It is obvious, therefore, that milk can be sent long distances, and yet be supplied in a good condition to the consumers without the addition of any preservative or the aid of heat. By efficient cooling milk can be kept from becoming sour for many days, but something more than mere cooling is required for the supply of pure, clean milk, and whether the milk be preserved by cooling, pasteurizing or sterilizing, the public ought to be assured that the original milk was 'clean'—that is, that it was produced under cleanly conditions, with access of the smallest

[1] Report of Departmental Committee. [2] *Ibid.*

possible number of microbes, and that the preserving process took place before the bacteria had had time to produce any deleterious products. If clean milk is to be supplied it must be clean from the beginning, and to secure this, attention must be given to (1) the cows, to (2) the cowsheds, and to (3) the milkers and the process of milking.

1. **The Cows.**—These should be healthy. The owner should exercise continual watchfulness, and at once separate from the herd any animal found to be showing signs of general illness, exhibiting any eruption on the udder or teats, or any affection of the udder, and no milk therefrom should be sold for human consumption. No person would willingly or knowingly drink milk from a diseased cow, and he has a right to insist that no such milk should be supplied to him. Unfortunately, as the law at present stands, the taking of this precaution cannot be legally enforced, but it is probable that, under the 'Sale of Goods Act,' if any person suffers loss or injury from the use of milk from an unhealthy cow he could recover damages from the person who supplied the milk. When the provisions of this Act become better known actions for damages will be more frequent. It ought to be a penal offence to sell milk from a cow suffering from any disease unless a certificate has been obtained from a veterinary surgeon to the effect that the affection is one which cannot possibly impair the quality of the milk.

2. **The Cowsheds.**—The cows should be kept under healthy conditions. When they are housed in cowsheds these should be clean, roomy, well ventilated, and well lighted. A cow can no more be kept in perfect health in a dirty, stuffy, ill-ventilated, and badly lighted shed than can human beings under corresponding conditions. A cow should not be regarded merely as a milk-producing machine, kept for the purpose of producing the maximum amount of milk, irrespective of its quality, but as an animal for producing a pure milk of good quality. To secure the requisite cleanliness the floor of the cowshed should be of hard and impervious material, and be properly drained. The

ventilating arrangements should admit sufficient fresh air, without causing unnecessary draughts, and the lighting should be such that all parts of the shed can be distinctly seen, and so arranged that the milkers can see what they are doing and have no excuse for not observing dirt on the cows' udders or flanks. The floors should be thoroughly cleansed daily and the cows groomed regularly. A dirty cowshed not only affects the cleanliness of the cows, but also the purity of the air in the cowshed, increasing the number of bacteria which enter the milk in the process of milking.

3. **The Milkers and Process of Milking.**—The milkmen and milkmaids should be taught the necessity for cleanliness: cleanliness of the cow, cleanliness of their persons and especially of their hands, and cleanliness of utensils. They should be provided with soap and water and clean towels, and it should be someone's duty to see that they use them. Clean overalls should be provided for use when milking, and the milking-stool should be kept scrupulously clean. The milk pail usually employed is a most unsuitable utensil, exposing the maximum amount of milk surface to the possibility of contamination. A closed can with a small projecting funnel about 6 inches in diameter is far preferable, since it reduces the area of the surface exposed to about one-sixteenth. In many dairies great attention is given to the scalding of cans, whilst everything else is neglected, but in some instances even the cans are not carefully cleaned. Such vessels are too often washed in water derived from brooks and ponds, and of a grossly polluted character. Cleanliness cannot be secured without an abundant supply of good water, and unless a farm commands such a supply it is unfitted for dairy purposes. In cleaning utensils the water must be properly used. It will not efficiently sterilize the cans, strainers, &c., unless it is employed at boiling temperature, and it will not remove grease unless a little soda is added to it. After washing, a final 'steaming' is desirable, after which the cans may be placed upside down on clean racks to cool and dry.

As no practical precaution can prevent the access of hairs and dust to the milk, some kind of straining is always necessary. The ordinary wire strainer is of very little service. The milk should be passed through two or more layers of cloth or through some of the pads now sold for the purpose, or filtered upward through sterilized sand, &c., as is done in some parts of Denmark. A few large companies adopt a somewhat different method of removing particulate matter, passing the milk through a centrifugal machine and afterwards mixing the milk and cream together. It is surprising to find what an amount of slimy matter adheres to the side of the machine when a sample of ordinary clean milk is passed through. This process fails unless the machine is thoroughly sterilized before use. Recently one of us had occasion to examine a sample of milk before and after centrifugalization, and found more bacteria in the finished product than in the original milk.

Milk which has been produced under the conditions and with the precautions described may be considered to be 'clean,' and it now remains to discuss how it can be maintained in this condition for a reasonable length of time without the addition of preservatives. This may be done either by the application or withdrawal of heat, but inasmuch as the application of heat affects to some extent the character of the milk, whilst the withdrawal of heat, or cooling, has no such effect, the latter is to be preferred and will be considered first.

Refrigeration.—From what was said with reference to this subject in Chapter I., it is obvious that the bacteria in milk multiply with such rapidity at ordinary temperatures that refrigeration, to be effective, must be carried out at the earliest possible moment after withdrawal of the milk from the cow. If the milk has been very carefully collected and is promptly cooled down to 50° F. it may be kept for forty-eight hours without the bacteria present reaching a million per cubic centimetre, but if not collected with special care it might contain two or more millions at the end of that period. At 40° F. a carefully collected milk will keep upwards of forty-

eight hours and remain perfectly fresh and free from any excessive number of bacteria. The following table, compiled from the experiments of Parks, shows the effect of keeping at these temperatures of milks taken (*a*) with special precautions, and (*b*) with ordinary precautions. It will be observed that the former (*a*) after keeping 96 hours at 40° F. is far better than the same milk kept only 48 hours at 50° F., and nearly as good as (*b*) after keeping twenty-four hours at 50°.

Number of bacteria per c.c.	(*a*) Milk drawn with special precautions		(*b*) Milk drawn with ordinary precautions	
	40° F.	50° F.	40° F.	50° F.
When freshly drawn	2,400	2,400	30,000	30,000
After 24 hours . .	2,500	11,600	38,000	89,000
After 48 „ . .	3,600	540,000	56,000	1,940,000
After 96 „ . .	218,000	—	4,300,000	—

We may take it, therefore, that it will suffice to cool the milk down to 50° F., if the milk can be kept at this temperature and supplied to the consumers in less than twenty-four hours, but if for any reason it has to be stored for a longer period, or cannot be kept continuously at 50°, it should be cooled down to 40° F. in the first instance.

For cooling to 50° F. spring or well water, used with a suitable refrigerating apparatus, will usually suffice. Deep-well waters can rarely be used, as the temperature often exceeds 50°. Rainwater stored in large underground tanks may be kept sufficiently cool for the purpose. In many districts sufficient snow can be collected during the winter to serve for the summer months. Certain farmers near Manchester[1] have been able to do this for many years, and report that the cost does not exceed 2*s*. 6*d*. to 5*s*. per ton. The snow is stacked in the open, with a covering of peat moss or sawdust about two feet thick.

For temperatures below 50° F. a special cooling plant is necessary in summer, unless ice or snow is available. There are several makes of machines which are specially adapted for

[1] Report of Departmental Committee.

this purpose. By one of the machines a stock of brine can be cooled to about 20° F., and this is used in the refrigerating apparatus for cooling the milk.

If carriage by rail is necessary the cooled milk should be despatched without loss of time in sterilized churns, so constructed as to exclude dust, and carefully cleaned before use. There is no doubt that a considerable portion of the advantage gained by the cooling of milk at the farm is lost by exposure to the sun before the churns are placed in the train, and by the unsuitability of the wagons used for the milk traffic by many of the English railway companies. If possible special vans should be used for this purpose, and though these are provided on many of the larger lines, there is still much room for improvement in this direction. In reply to inquiries by the Departmental Committee, it appears that two of the Southern lines provide no special trucks for milk, and that on no line are the walls or roofs double, whilst ice-wagons are unknown. Most of the companies take no special precautions to keep the wagons in the shade when not in use.

This is not a matter in which the railway companies are likely to make improvements unless pressure is brought to bear upon them, and this can only be done by the large dairy companies into whose hands the milk supply of the towns is rapidly passing.

On arriving at its destination, if the milk is not immediately distributed, the cooling should be maintained, and scrupulous cleanliness again observed.

As an example which might well be aimed at in this country, the following extracts from the account given of a visit paid by some of the members of the Departmental Committee to the premises of the Copenhagen Milk Supply Company may be of interest:

'The business premises are situate at Frederiksberg, and they have in all entailed an outlay of about 15,000*l*. There are employed some 170 adults and 160 boys, and fifty-eight horses are in working. The water supply is from a well in the yard, taken

from a depth of 51 feet from the surface. The water contains much iron and is filtered before use.

'The ice-house has double walls, with intervals of 2 feet, the space being filled with sawdust, and beneath the floor there are arrangements for draining off the water resulting from the melted ice.

'In August last, thirty-five farms were sending milk to the company. Every farmer's milk is tested, from 100 to 120 samples being chemically analysed, and some 40 samples physically examined, each day. Cows furnishing the milk must be kept in the fields till mid-September. The application of the tuberculin test is now not compulsory. Much of the milk comes by rail in special ice-wagons belonging to the company. Ice is introduced by openings in the roof into ice receptacles situate at either end of the wagon, the receptacles being provided with waste-pipes for the escape of melted ice. The ice is put in at the city premises, in order that the wagons may be sent back with the empty churns in a cool atmosphere. The air of one wagon was tested and found to have a temperature of 14° C. (57° F.) on a hot August night, the wagons having finished a day's travelling to the farm stations. The temperature was 17° C. (63° F.) at 7 o'clock A.M. after the doors had been open all night. Each wagon takes 1,000 lbs. of ice, and holds 105 milk cans, each containing 50 litres. The ice comes from Danish lakes, and costs 2*s.* per 1,000 lbs., including labour of housing it in the huge store chambers.[1] The charging of a wagon costs about 2*s.* 6*d.* About five million pounds of ice were used in 1889 on the premises.

'Milk comes a distance of from 10 to 50 miles, the longest distance occupying three hours in actual transit. It leaves the country stations from 7 to 7.30 P.M., and reaches the premises in Copenhagen from 10 P.M. till midnight. The ice-wagons are attached to passenger trains.' The milk is despatched from farms so as to reach stations only half an hour before the departure of trains.

[1] Ice costs 16 kr. (17*s.* 10*d.*) per ton when imported from Sweden.

'Milk is sent out for delivery in the city only once daily, so that although customers get their day's supply in two rounds, it is the same milk, the carts doing the circuit twice for the convenience of householders. No complaints have been received from customers. On Sundays only one delivery is made. Forty carts start about 5 to 6 o'clock in the morning, each cart having its specified "round." At the houses of the customers the milk is emptied from the churns into small "cans," and from these into the domestic receptacles provided by the householders. The taps of the churns on the carts are covered by metal flaps to prevent the ingress of dust and dirt to the muzzles, and special milk in bottles is placed in ice in a separate covered part of the van. Superfluous milk left over after the day's distribution (some 5 per cent. as a rule) is put through a separator, and the resulting cream made into butter.

'The farms furnishing milk have an average of 150 cows each. The conditions which regulate the feeding of milch cows, their milking, the delivery of milk, &c., are very strict, and have been in existence for many years. A translation by Mr. A. Stewart-Macgregor, late British Vice-Consul at Copenhagen, runs as follows :

'REGULATIONS FOR CONTRACTORS.

'A.—*Feeding and Management*

'I.—The food of the cows must be of such a nature and quality that no bad taste or taint may be imparted to the milk by it.

'(*a.*) Brewers' grain and all similar refuse from distilleries are strictly forbidden, as also is every kind of fodder which is not fresh and in good condition.

(*b.*) Turnips, kohl-rabis, and ruta-baga are absolutely forbidden. No kind of turnip leaves may be used.

(*c.*) Carrots and sugar beets (mangolds) are permitted up to half a bushel per cow, but only when at least 7 lbs. corn, bran, and cake are given along with them.

Cows supplying infant milk may get carrots, but never more than a quarter of a bushel per head.

'(*d.*) Oilcake. Rapeseed cake is the only oilcake which may be used; 1½ lb. is the furthest limit, along with at least 5 lbs. corn and bran. Infant milk cows must not receive any cake.

'(*e.*) The proportions in which the different kinds of food are to be given must be arranged with the company before the contractor commences to supply milk.

'II. Stall feeding in summer will not be permitted under any circumstances. The cows must be fed in the open air upon clover and grass. Vetches are forbidden. In case of necessity dry food or cut corn may be given, but on the field.

'III. In autumn the cows must be clipped on the udder, tail and hind quarters, before being taken in.

'IV. Calving should be so regulated that the milk sent in during the months of September and October is not less than two-thirds of the largest quantity in any other month.

'V. The milk of cows newly calved must be withheld for twelve days after calving, and must not be less in quantity than 3 imperial quarts per day.

'B.—*Milking*

'VI. The greatest cleanliness must be observed during milking, and the milk must be strained through a wire sieve, covered with a clean woollen cloth.

'VII. Immediately after milking, and during all seasons of the year, the milk must be cooled down with ice-water to 40° Fahrenheit.

'VIII. Every contractor must be provided with a Lawrence cooler, which he can obtain on hire from the company.

'IX. Thirty pounds of ice, making due allowance for waste, must be kept in stock for every 100 lbs. milk produced, which can be calculated from the fortnightly trial milkings.

'C.—*Delivery of Milk*

'X. (*a*.) The milk must be delivered at the nearest station once or twice daily, according to the requirements of the company, either as whole milk, or as 'half-skimmed' milk and cream.

'(*b*.) The milk must not be sent from the farm earlier than is absolutely necessary for its arrival in proper time at the railway station.

'*c*. In summer the van for conveying the milk to the station must be provided with a cover to protect the milk from the heat of the sun.

'XI. The company will supply the cans necessary for transport.

'XII. The company cleanse the cans before returning them, but they must be carefully rinsed out with cold water as soon as they reach the farm again, to get rid of any dust or dirt which may have adhered to them during the return journey.

'The cans must be placed in a cool airy spot, until again required, protected from all impurities, with lids off, and bottom upwards, but in such a position that the air can freely get into them.

'XIII. The cans may not be used for any purpose but the conveyance of milk.

'D.—*Further Regulations*

'XIV. The contractor is bound, upon word of honour, to answer any inquiries made by the company concerning the milk supply.

'XV. The contractor must allow any of the veterinary surgeons of the company to inspect his cattle as often as the company requires, and must drive the surgeon to and from the station. The contractor is bound to follow out closely the instructions of the veterinary surgeon.

'XVI. Any cow declared by the veterinary officer to be suffering from tuberculosis must be instantly and entirely separated

from the rest of the herd, and should be got rid of as soon as possible.

'XVII. The contractor must promise immediately to inform the company of any case of illness which may arise between two visits of the veterinary officer. If necessary, he must withhold his milk until the veterinary officer arrives and inquires into the circumstances.

'In such a case the full price will be paid for the milk.

'XVIII. The contractor, to the best of his ability, must watch over the health of all who reside on his farm, or work upon it; also the families of the latter.

'Should a case of infectious disease arise among any of them, he must immediately report the fact to the company, and withhold his milk, which will nevertheless be paid for as usual, if these conditions are fully complied with.

'XIX. Either of the contracting parties, after having given six months' notice, can terminate the contract on the following 1st of January.

'XX. Should the company find the milk of inferior quality, and therefore unfit for sale, they shall be entitled to refuse to take it, without giving any compensation to the contractor.

'XXI. If owing to an epidemic, or other unavoidable cause, the sale of milk in Copenhagen should be suspended, the contractor must withhold his milk for a shorter or longer period without compensation.

'The milk is placed in ice-water almost immediately after arrival on the premises of the company. It is taken from the wagons as soon as they can draw up at the special siding for unloading, the cans being raised to the level of the floor by a miniature lift. The temperatures of different milks taken haphazard on a hot night were 13°, 13°, 13°, 16°, 16° C., and one was 17° C. It would be about 6° C. when it left the farm, and all milk was again cooled down to that degree (43° F.) Women test the sweetness of the contents of each milk-churn, and throw aside the sample tested; and it is stated that not even so rarely as once a month has milk to

be rejected. Each churn's milk is also tested as to temperature, and a register kept. Each can bears a seal showing its source of origin. The milk remains standing in ice-water till morning, save that for children, which stands only half an hour for purposes of cooling.

'Besides the cooling on reception by the company, milk has also to be cooled at the farms, the morning milk being kept in ice-water, and sent up with the evening milk, but in separate cans. The evening milk is sent whole, but, as a rule, only the cream of the morning milk.

'Milk is screened at the farms as soon as practicable after being drawn. It is screened in the fields in summer, the milk of every two or three cows being put through a fine wire gauze covered with a cloth. Cows are milked in the sheds in winter, the milk being drawn away at once and screened.

'The milk is efficiently filtered at the company's premises through four layers of gravel of varying sized pebbles, and three layers of cloth. There is also a smaller filter with two layers of gravel and two of cloth to be used only for any small amount of milk urgently needed. The gravel is washed with hydrochloric acid, and also with soda and water, and sterilized at 120° C. (248° F.) after each time of using. It is then dried in a high-pressure steam oven. The process of filtration is upward, first through the lowest layer of coarse gravel, then through the intervening finer layers to the cloths of close texture. Before being filtered, the milk that has been standing to cool is intimately mixed with a perforated crescent-shaped metal disc, and stirred to obviate any unequal distribution of cream.

'The milk can be kept sweet in the hottest weather. No trouble has been felt in the twenty-three years during which the company have been working. Milk drawn one morning will not in ordinary course be all of it used till the evening of the next day; and this after having left the establishment about 6 o'clock on the morning of the day succeeding its being drawn, for delivery on two rounds to customers.

'Milk for children comes from special farms, and is watered

down for infants with water which has passed through a Pasteur-Chamberland filter, which is cleansed weekly. All such milk is bottled in $\frac{1}{4}$, $\frac{1}{2}$, and 1 litre bottles, and sold at $2\frac{1}{2}d.$ per litre. The filled bottles are kept in ice, both on the company's premises and in the covered carts.

'Great attention is paid to the cleansing of milk and butter receptacles by the company. The workers throughout the establishment are all in white, and are supplied with clean covering aprons twice weekly. The cans are cleaned by brushing with hot water and soda, and later washing out with hot water and lime, a ladleful of soda, about $\frac{1}{2}$ lb., being used for each pail of water, and 20 lbs. of lime to 900 litres of water. The outside is then washed and steam injected into the cans, which are left to drain alike by the company's servants and by the farmers. The latter have not their own cans. The apparatus in which the cans are washed is itself subjected to like cleansing. Bottles are first washed in soda and water, then placed over revolving brushes, and then steam-sprayed. The corks, which are used only once, are of special make, and are tied by hand and sealed. The butter pots and lids are washed in soda and water, and the pots only in lime and water also.'

Pasteurization and Sterilization.—The former term as applied to milk refers to the process of heating to a temperature exceeding 140° F., but less than 212° F., for a period varying from five to thirty minutes, whereby all bacteria except those which are spore-bearing may be assumed to be destroyed. It is doubtless this wide range in time and temperature which is responsible for the different opinions expressed with reference to the properties of pasteurized milk (and cream). This difference extends even to the flavour, some asserting that pasteurized milk has a different flavour from raw milk, others denying this, or affirming that no difference can be detected if the milk is cooled rapidly after heating.

The process of sterilization differs from the one just described, inasmuch as the milk is kept at a temperature at or exceeding 212° F. for a period sufficiently long to destroy the

spores of any bacteria which may be present. This is a twofold advantage, since the milk is not only entirely freed from organisms, but will keep for an indefinite period if delivered sealed in the bottles in which it has been sterilized. In the homes of the poor, where proper storage is always difficult and often impossible, especially in summer, this advantage is very considerable, but unfortunately such milk must be sold at an enhanced price, and this is an effectual bar to the general adoption of the process.

Both sterilization and pasteurization should be effected as speedily as possible after the milk has been taken from the cows, otherwise the bacteria present may produce deleterious substances not capable of being destroyed by the subsequent heating.

Effect of Heat upon the Milk itself.—This is a most important subject, and one which has received a good deal of attention both from chemists and physicians during recent years. It is obvious that if the digestibility of the milk is decreased or its nutritive value impaired, the advantages to be obtained by the heating process are diminished. It then merely becomes a question as to whether the advantages outweigh the disadvantages, and this we shall discuss presently. Milk undoubtedly does undergo some change when heated, and although the nature of the change is difficult to demonstrate, the fact that there is a change can be shown by simple chemical tests, even when the heat applied has not been sufficiently great to effect any alteration perceptible by the unaided sense of sight or taste or smell. Boiling increases the opacity of the milk and causes the formation of a film, changes obvious to the unaided senses. When the heat has not been sufficiently great to produce these obvious alterations chemical tests will still show that a change has taken place. Boiled milk requires a larger proportion of mineral acid for coagulation than raw milk, and under the microscope the fat globules are found to be larger after boiling. According to Rotch lactalbumin is coagulated at 162° F., and the rennin enzyme rendered inert at 165° F., hence we may assume that

both these changes will generally have taken place in pasteurized milk. The phosphates present in milk appear to be attached to the proteid matter, but the combination is so easily broken down that the application of heat results in the separation of insoluble phosphates of calcium and magnesium. Milk contains according to Soxhlet about 0·1 per cent. of citric acid, and Dr. Netterdrew asserts that prolonged heating in some way diminishes this amount, arguing therefrom that as citric acid is an antiscorbutic, its removal or partial removal from milk causes or predisposes to scurvy-rickets amongst young children fed on such altered milk. De Rothschild and Abramoff believe that there is a sort of auto-peptonization of the milk during the first stage of sterilization, before the temperature rises sufficiently high to destroy bacteria. This peptonization is said to take place very rapidly, and it is argued that, as the subcutaneous or intravenous injection of peptones in small quantities is followed by hæmorrhages and other symptoms of scurvy, the administration of auto-peptonized milk may give rise to the same symptoms.

Others assert that raw milk possesses distinct germicidal properties and that these are lost after heating; moreover, that this change, and the coagulation of the lactalbumin, and the alteration in the casein, rendering it less precipitable by rennet, all make the milk less digestible. After sterilizing by heat the slight power possessed by milk of acting upon starch is lost, and cream separates more slowly and in smaller quantity. All the above facts indicate that such milk differs considerably from raw milk.

Do these changes affect (*a*) the digestibility of milk, or (*b*) its nutritive value? These are most important points, and the opinions expressed are of a very conflicting character. It is held by some that the pasteurized or sterilized milk is as digestible and as good in every other respect as raw milk, whilst others contend that it is less digestible, and that children fed upon it are liable to attacks of infantile scurvy and rickets.

With reference to the relative digestibility of raw and boiled milk, it seems probable that individual idiosyncrasies may account for the different results obtained by different observers. Thus Hutchinson says that boiled milk clots in the stomach exactly in the same way as raw milk; whilst others argue that, because the clot formed *in vitro* is less dense and appears more slowly after the milk has been boiled, it must do the same in the stomach. Even if such were the case this is no proof of the digestibility being decreased or the nutritive value impaired. On the contrary, some assert that the use of boiled milk prevents the formation of compact curds in the stomachs of children, and is therefore an advantage. Many experiments have been made by swallowing definite quantities of milk and washing out the stomach after known intervals. The results of these experiments are conflicting, some observers finding that the raw milk is more quickly digested, and others that the boiled milk more rapidly disappears. The difference in any case cannot be very great, and may depend upon the individual. The more serious charge against pasteurized and sterilized milks, that they tend to produce a form of scurvy, is based on the observations of physicians and may be founded on fact.

Dr. Clement Dukes[1] has very strong views on this subject. He believes that the use of cooked milk is the cause not only of infantile scurvy but also of rickets; he maintains that the injury inflicted upon the children of the present generation by the use of cooked milk far exceeds that caused by the use of raw milk. He quotes the results of the investigation made in 1896 by the American Pædiatric Association on the nature of the food used by children suffering from infantile scurvy; 379 cases were investigated with the following results:

Food	No. of cases
Breast milk	10
Breast milk with other foods	2
Raw cows' milk	5
Pasteurized milk	20

[1] *Lancet*, January 31, 1903

Food	No. of cases
Condensed milk	60
Sterilized milk	107
Proprietary foods	214

The total, 418, is due to the fact that children fed on more than one kind of milk are enumerated under each appropriate heading; thus a child which had been fed on sterilized milk and some patent food would be entered under both. There is a fairly general consensus of opinion amongst those who have studied the subject and had the opportunity of making observations, that scurvy-rickets occurs chiefly amongst the children of the better classes, and especially amongst those who take the precaution of boiling all milk before allowing it to be used, or who purchase sterilized milk. Children using such milk are not infrequently found to show signs of impaired nutrition, yet to improve rapidly when raw milk is substituted for the sterilized. Frequently, however, proprietary foods are used with the milk, and many of these are well known to tend to cause scurvy-rickets.

This subject is becoming increasingly important on account of the number of towns in which the authorities are establishing depots for supplying 'humanized milk.' This system was started in France, and in several towns humanized sterilized milk has been supplied by associations for over ten years. The milk is properly prepared, measured into bottles, each containing sufficient for one meal, and then sterilized, after which the bottles are sealed and the milk distributed. The infants using the milk are weighed each week, and a record of their weight and general condition is kept. Dr. Variot, who has made a special study of this subject, says that at some depots 150 to 200 children are constantly under observation. Many of these when they first come under observation at the depots are in a wasting condition, some are in an advanced stage of atrophy. 'The tracings of their growth, without being as perfect as in the case of infants nursed by their mother, are nevertheless satisfactory in general.'[1] The proportion of infants incapable

[1] Dr. Ransom, *British Medical Journal,* February 22, 1902

of assimilating the milk does not exceed 4 per cent. of the total number using it. He has never met with a case of rickets or infantile scurvy which could in any way be attributed to the sterilized milk. Dr. Ransom, referring to the results obtained at the Nottingham General Hospital, where the milk is sterilized by being kept at the boiling-point for about ten minutes, says that the improvement which occurs in the nutrition of wasted infants brought into the hospital is rapid and striking, and he has never known scurvy-rickets or atrophy result from the feeding of infants with such milk. Dr. Ransom quotes the experience of other physicians to the same effect. One of us has made inquiries from the medical officers of the English towns where such milk depots have been in existence two years and upwards, and they are unanimous in asserting that no harmful effects of any kind result from the supply of sterilized milk, and that the children fed thereon thrive lustily, and are less liable to suffer from infantile diarrhœa than those fed on raw milk. When we consider also that on the Continent it is the rule to sterilize milk before use, and that cases of infantile scurvy and scurvy-rickets are very rare, it is obvious that the danger of contracting these diseases from the use of boiled milk is very slight indeed, and has been grossly exaggerated. It is possible, however, that even the infinitesimal danger could be avoided if milk were merely pasteurized instead of being sterilized. The distribution of pasteurized milk could only be effectually conducted by associations or public authorities. This is done in Copenhagen by an association called 'The Milk Supply Pasteur,' and the following description of the methods of preparing and distributing the milk is taken from the report of the Departmental Committee on the use of preservatives:

'This firm, which has been in operation for five years, and which deals in the main with bottled milk, was devised and projected by Director Krohne, and with the scientific co-operation of Professor Faber and Dr. Schierbeck of Copenhagen. The staff is a large one, 300 workers, including boys, being

employed, and eighty horses being necessary. There is an ice-making plant on the premises. About 40,000 bottles of milk are pasteurized daily.

'The farmers supplying the milk are under detailed control, and every month or three weeks the farms are visited by a veterinary surgeon attached to the establishment. There are fixed regulations as to the fodder of the cows, for treatment of the milk, and for the notification of tuberculosis.

'The institution itself is situated in the outskirts of Copenhagen, and the railway wagons which convey the milk to Copenhagen are not provided with ice-chambers. The milk on reaching the factory is received into a reservoir, when it is duly weighed and strained, and from this it is pumped to a filter consisting of layers of gravel and felt, the whole apparatus being carefully sterilized daily.

'After filtration the milk passes to the cooling apparatus, and from this to a second reservoir, from which it is pumped to the pasteurizing apparatus (which is also sterilized daily after use), where it is raised to a temperature of 85° C., the whole process being so arranged as to exclude the admission of air-borne organisms. The milk is then cooled to about 3° C., the pasteurizing and cooling occupying altogether about five minutes. From the cooler the milk is led to a reservoir, also guarded against the entry of extraneous organisms, and from there to the bottle-feeding apparatus, a machine fitted with tubes, by means of which the bottles can be conveniently filled.

'The bottles, which are furnished with glass stoppers, are, after being filled, carefully sealed to prevent their being tampered with.

'The employees who are brought in contact with the milk are all under medical supervision. In the event of their being ill they are refused admission to the factory, and the same exclusion obtains if infectious disease is present in their homes. They receive under such circumstances full pay during their absence.

'The bottles which are used for small quantities of milk, as also the cans which are used for large institutions, are first thoroughly cleansed in hot water to which soda has been added—the interior of the bottles being washed out by means of revolving brushes—and after this they are completely sterilized in a large steam disinfector, which is kept at a temperature of 105° C. for half an hour.

'The several processes are daily under control, both chemically and bacteriologically. Specimens of pasteurized milk are tested daily by Professor Storch's reaction to ascertain whether or not pasteurization has been properly accomplished. Bacteriological examinations are made daily, and the percentage of fat is also estimated.

'The advantages claimed by the process may be thus summarized:

'1. All danger from the possibility of infection of the milk, either at the farms or during transit, is thereby discounted.

'2. The distribution of the milk in sealed bottles is a safeguard against its infection or contamination in the milk shops or in the streets.

'3. The milk awaiting consumption in the houses is kept free from contamination by means of flies, dust, or polluted air.

'It is claimed that this is the only practicable bottle system for milk at moderate price, and that the pasteurization of the milk places less onus on the farmers as to cooling, &c.'

Although this company sends the milk out in bottles chiefly, there is no reason why the distribution should not take place in the usual way, if desired.

The chief objection to these heating processes is that they are not necessary, since a simpler method is available for keeping milk sweet for a reasonable time, a process which does not reduce its nutritive value in any way: we refer to the preservation by 'cooling' of milk from healthy cows, collected under sanitary conditions. This will, of course, necessitate proper supervision of the cows, the proper construction of cow-sheds, cleanly methods of milking and of storing milk.

No doubt all this means trouble to the farmer, trouble which he is averse to taking and probably never will take. If such is the case, the next best plan is to pasteurize the milk, thereby killing all the known disease-producing organisms, and most of the other organisms which enter the milk from diseased cows, dirty udders, dirty milkers, unclean utensils, &c.

To sum up what has been said with regard to milk, we are of opinion that if chemical preservatives are added the quantity of the latter which will be consumed by infants and children and invalids is so considerable that there is an appreciable danger of injury to health, partly owing to the comparatively large amount of the antiseptic necessary for efficient preservation, partly to the opportunities which occur for repeated addition of the preservative, and partly to the difficulty of enforcing declaration or any legal limit. With the present system of house-to-house delivery it is obviously impossible for the presence of a preservative to be efficiently declared. The addition of preservatives is particularly objectionable in the case of infants and of persons suffering from certain diseases in which milk is largely employed as a food, and in which the preservatives commonly in use are contra-indicated on account of either deficient excretory power or abnormal conditions of the digestive organs. To this may be added the idiosyncrasy which undoubtedly exists with regard to boric and salicylic acids.

On the other hand, due consideration should be given to the effect of partially decomposed milk, during the hot weather especially, a change which is to some extent checked by the introduction of antiseptics; and there is no doubt that, with the milk as it is, this is a real danger, and it must continue so until the traffic is conducted on more enlightened principles as regards cleanliness, asepsis, and refrigeration.

We have, however, indicated methods by which too rapid change can be prevented, and the milk kept perfectly sweet and wholesome for a sufficient length of time. Of the two, refrigeration and pasteurization, the former is in our opinion

greatly to be preferred, as it necessitates cleanliness in the production of the milk, whilst pasteurization and sterilization will tend to the negligence of the precautions necessary for the production of a pure, clean milk. Whichever is adopted, the keeping of milk in the dwellings of the poor will always be a difficulty, but it may in a measure be overcome by the gradual spread of education, and the improvement in the housing of this portion of the community.

Looking at the subject purely from the sanitary standpoint, the case against the use of preservatives is a clear one. What the effect of the prohibition of their use would be on the small retail trader is a matter for conjecture. It would probably result in his disappearance except in rural districts; and already this process is in progress in large towns, where dairy companies are gradually displacing their smaller rivals. This is not an unmixed evil, if it can even be called an evil, since many retailers in towns carry on their trade in premises quite unsuited for the business. This natural disappearance of the less fit will cause less outcry than the enforcement of oppressive (?) measures by the local authorities.

These views are to a large extent borne out by the evidence given before the Departmental Committee, by many witnesses connected with the dairying industry. Whilst some of them considered that the prohibition of the use of preservatives would result in the monopolization of the milk trade by large companies, others admitted that every town could be supplied with good milk free from preservatives, and were ready to welcome the prohibition of their use. In fact the Dairy Produce Association of the Central Chamber of Agriculture forwarded to the Departmental Committee the following resolution:

'That this meeting is opposed to the employment of preservatives (and colouring matter) in articles of dairy produce, whether British or imported, and that it be an instruction to the witnesses appointed by this Chamber to give evidence before the Departmental Committee to urge

that, as preservatives (and colouring matter) are believed to be deleterious to the health of invalids and children, their use should be prohibited.'

In this country we are far behind others in appreciating the dangers arising from the use of unclean milk, and in the steps taken to prevent the injury arising therefrom. We have already referred to what is being done in Copenhagen, and the action now being taken by the city of New York is well worth consideration, as it will probably be of greater advantage than the mere establishment of depots from the sale of humanized milk for children only. Dr. Chapin is the originator of the scheme for providing a pure milk supply by the simple method of cleanliness and cooling. Through his efforts a Committee of the Medical Society of the County of New York held consultations with the milk dealers, with the result that a series of rules were drawn up, and the milk dealers complying with them were authorized to use caps on their milk cans stamped 'Certified by the Commission of the Medical Society of the County of New York,' or 'Inspected Milk Commission Medical Society, County of New York.'

A full account of the rules is given in the 'British Medical Journal,' April 18, 1903. In view of the general opinion of English farmers, one of the most interesting regulations for the 'inspected' milk is to the effect that it must 'average 4 per cent. of butter fat.' The cooling of the milk must commence within thirty minutes from the time of milking, and the temperature of the milk must be reduced to 55° F. within two hours, and to 50° F. within three hours, and be kept at this latter temperature until delivered to the consumer. When delivered it must not average over 100,000 bacteria per cubic centimetre from May 1 to September 30, and not over 60,000 from October 1 to April 30.

The provision of pure milk, without resorting to pasteurization or sterilization is, however, now receiving increased attention in this country, and there are grounds for hoping

that improved methods will gradually become more widely adopted.

Among other instances may be mentioned the model farm at Sudbury, Middlesex, and a private farm near York managed by Mr. Sorensen. Mr. Sorensen is of opinion that clean bottled milk could be retailed at the same price as is at present obtained for ordinary milk, if customers would be content with a single daily delivery, as in many towns abroad. In Leeds the City Council had for some time considered the question of providing a depot for the distribution of bottled milk chiefly for the poor, and, after making many inquiries into the advantages and disadvantages of sterilization and pasteurization, it was decided in the first instance to rely upon cleanliness, straining, and refrigeration alone. Owing to certain legal difficulties of a financial character, the Council were unable to undertake the entire management, but a depot has been started by means of private subscriptions which promises to give favourable results, and this will no doubt be continued by the Council when the necessary powers have been obtained. A contract has been made with a farmer, whose farm premises are of a satisfactory nature, for the supply of milk under conditions of strict cleanliness. The milkers are provided with clean overalls, and are required to keep their hands in a cleanly condition. The cows are examined at frequent intervals by a veterinary surgeon, and their udders and flanks are cleaned prior to milking. The process of milking is periodically supervised. All the vessels employed are thoroughly scalded after use. The cows are milked in their byre, but it is probable that in course of time a special shed will be found to be desirable for this purpose. The milk is at once removed to a building only a few minutes' distance from the farm, where it is strained through a filter, passed over a cooler supplied with ice-water, and at once bottled into sterilized stoppered bottles, which are then placed in ice. The morning's milk is ready for distribution by about 10 A.M., and the afternoon's by about 6 P.M.;

the latter is, however, usually kept in ice until the following morning.

Too short a time has elapsed to form a complete opinion as to the success of the scheme, but the results of repeated bacteriological examinations are encouraging, both as regards the total number of organisms present, and the presence or absence of organisms of the B. coli group. It is the exception for the latter to be absent in $\frac{1}{10}$ to $\frac{1}{1000}$ c.c. of ordinary milk, whereas they have only been found on very rare occasions in similar quantities of the bottled milk. The afternoon milk, as sold the following morning, frequently contains less than 10,000 organisms per cubic centimetre. The bacterial contents of the morning milk are usually higher, the difference probably being due to the cleanlier conditions of the byre in the afternoon. It will probably be necessary to have a special shed for the milking process, as time does not allow for a thorough cleansing of the byre before the morning milking takes place.

In concluding this section certain recent introductions, which may have some effect on our milk supply, may receive brief reference. The first is the preservation of milk, after pasteurizing at a rather low temperature, by the introduction of a mixture of carbon dioxide and oxygen. The company which owns this patent claims that milk so treated will remain sweet for several months. The process is somewhat as follows. The milk is first heated to 150° F., and then forced in a fine jet against an agate piston to break up the fat globules. It is then cooled to 40° F., and charged in bottles with a mixture of 3 parts of oxygen and 1 part of carbonic acid at a pressure of 50 lbs. to the square inch. The bottled milk is heated to 150° F., then cooled, and the process is again repeated, after which the milk is ready for sale. The milk is said to be chemically unchanged, and to be as palatable as, or more palatable than, raw milk. The trouble and expense involved in this process will probably prevent its ever being widely adopted. In a previous section reference has been made to the use of peroxide

of hydrogen as a preservative for milk. In Denmark large companies have already adopted Budde's process in lieu of pasteurization, and it is alleged that the product keeps better and retains all the virtues of the raw milk which pasteurized milk admittedly does not. An attempt is being made to introduce the process into this country, and 'Buddeized' milk will probably soon be found upon the market. It can be delivered in the ordinary way, or in sealed bottles. In the latter case sufficient milk can be purchased at one time to last one or two weeks or more. If experience shows that the nutritive effects of the milk are not impaired there is no doubt a great future for this process, but it is sincerely to be hoped, that the fact that the milk will ultimately be sterilized will not lead to further carelessness on the part of the milk producers and dairymen. So far as can be ascertained, 'Buddeized' milk is superior to pasteurized milk, and if it can be sold at the same price as ordinary milk, as is alleged, it must command a large sale. Dr. Hewlett[1] says that 15 c.c. of a 3 per cent. hydrogen peroxide solution is required to sterilize one litre of milk, so that the quantity of water added to the milk amounts to 1·5 per cent. The cost of the chemical is insignificant, as dilute solutions are obtainable at about 2*s.* per gallon. The cost of the chemical would therefore be about one halfpenny per gallon of milk treated. The cost of the plant necessary is not great, but is probably more than the small farmers will care to lay out, in which case the milk supply will the more rapidly pass into the hands of the large companies, especially in towns. A third innovation is the introduction of 'dried milk.' This is a flaky preparation, made by the rapid evaporation of the milk at a temperature of from 220° F. to 230° F. The product is flaked, or converted into a fine powder, or compressed into tablets. One pound of the powder is about equivalent to 1 gallon of milk, and the solution in water has somewhat the appearance of milk and the flavour is apparently unaltered. Provided that good clean milk is used in the manufacture of the dried article,

[1] *The Lancet*, January 27, 1906.

and that the desiccation is carried out immediately after milking, the product from the chemical and bacteriological point should be excellent. The powder will probably be in great demand, but at present it is impossible to form an opinion upon its dietetic value, or to say whether its use will be liable to produce infantile scurvy or rickets. When dissolved in water the product differs little from the original milk, but the percentage of butter fat seems to be slightly lowered, and there is some change in the casein, which results, however, in its forming with gastric juice a fairly granular clot comparable with that from human milk. Medical men who have used it in institutions and in private practice regard the results as being satisfactory.

CHAPTER X

CREAM, BUTTER, MARGARINE

Cream.—The principal chemical substances used for preserving cream are the same as those employed for milk: namely, boron compounds, and formic aldehyde; the former is frequently combined with salicylic acid, salt, saltpetre, saccharin, and cane-sugar, but occasionally salt and saltpetre are used alone. The employment of 'saccharated lime' has already been referred to.

A much greater proportion of samples of cream contain these preservatives than occurs in the case of milk, owing, probably, to the fact that the former is largely sold by grocers, which entails storage for a considerable time.

This substance, in which the opportunities for bacterial pollution are equally great as in milk, is not often taken for analysis, but an idea can be obtained as to the prevalence of the use of preservatives when it is stated that the latter were found in all of six samples analyzed by Mr. Collingwood Williams, in seven out of eight samples by Dr. Hill, and in all of eleven samples supplied to St. George's and St. Mary's Hospitals.[1]

The following are the maximum quantities of boric acid which have been found by different observers:[2]

Authority	Percentage	Grains per pint
Mr. O. Hehner	0·800	70·0
Government Laboratory .	0·651	57·0
Dr. A. Hill	0·600	52·5
Mr. C. E. Cassal	0·515	45·0
Mr. James Hudson . .	0·450	39·4
Mr. W. C. Williams . . .	0·434	38·0
Mr. C. W. Sorensen . . .	0·225	19·7

[1] Report of Departmental Committee. [2] *Ibid.*

The amounts of the trade preparations of boron recommended for the preservation of cream vary from about 6·2 to 54·6 grains per pint expressed as boric acid, and similar quantities were stated to be used by various dairymen in supplying information with regard to this point.[1]

The difficulties which exist in estimating the quantity of formaldehyde apply to cream equally with milk. One example examined in the Government Laboratory was found to contain less than 1 part of formalin in 100,000, though it is doubtful if so small a quantity would have any considerable preservative effect.

Salicylic acid is, as has been mentioned, generally employed in conjunction with boron compounds, and only small and innocuous quantities would therefore be present, unless the mixture were recklessly used.

The same applies to salt and saltpetre, though the latter is occasionally used alone in the proportion of about 2½ to 3 grains per pint.

The question of the possible danger to health involved by the introduction of antiseptics is slightly different in the case of cream from that of milk, for, although larger amounts of these chemicals are necessary, in view of the longer period for which storage is required, the volume of cream consumed is very much less. Of the three preservatives, boric acid, formic aldehyde, and salicylic acid, the first is the least likely to be harmful, and if limited to one-quarter per cent. (a little over 20 grains per pint), as recommended by the Departmental Committee, there is little probability that any harm will result in the case of a healthy adult, even supposing that he consumed as much as 2 ounces of cream every day, a somewhat unlikely supposition.

On the other hand, cream is frequently administered, partly as a substitute for cod-liver oil, to infants, children, and persons suffering from anæmia, phthisis, and various wasting diseases. Even in this class of persons the small quantity of boric acid

[1] Report of Departmental Committee.

which would be thus taken is not likely to cause injury to health, unless further quantities are at the same time introduced in the various other common articles of food for which boron compounds are employed.

Occasionally, however, a mixture of cream and water is used as a substitute for milk for hand-fed infants with whom the latter disagrees: Biedert, for instance, recommends 4 ounces of cream with 12 ounces of warm water and half an ounce of milk sugar for a baby a few weeks old. This would result in a daily dose of 5 grains of boric acid, a very excessive quantity at such an age.

For the protection, therefore, of infants and invalids it is absolutely necessary that the preservative, if permitted, should be declared on the containing vessel, together with the quantity used, so that the medical man in attendance can forbid the use of such cream if he thinks it likely to do harm. Unfortunately the prevalence of the use of antiseptics and the possible effects of the amounts used are not so widely recognized by the medical profession as they should be, and the purchase of such articles of food is of necessity left to the head of the household, who cannot be expected to recognize the possible danger of the addition of preservatives. There is no doubt that, if prohibition were enforced, the supply of cream would be entirely limited to the fresh article, or to that which had been subjected to sterilization; but as it is a great convenience to be able to purchase cream from grocers and others who stock the article, possibly the declaration and limitation of the amount of preservative used would prove sufficient protection to the health even of those who take considerable quantities.

There is a further danger which must be borne in mind: namely, that if the preservative is simply powdered on the top of the cream, admixture will almost certainly not take place, and the top layer may therefore contain a very large quantity of the chemical. This has actually been known to occur.

That cream can be sold without a preservative is shown by the fact that the Aylesbury Dairy Company, who formerly

added 0·2 per cent. of boric acid, have for several years been able to supply cream absolutely free from antiseptics, and the same is the case of the cream supply in Copenhagen.[1]

A daily supply, in conjunction with the precautions as to cleanliness and refrigeration mentioned when the question of milk was discussed, are all that is necessary for this purpose.

The use of formalin is objectionable on two grounds: first, that as there is at present no reliable method of estimating the amount originally added, the enforcement of a legal limit is impossible; and second, that it appears to be a far more potent substance than boric acid, and likely, therefore, to act more injuriously on the human economy.

Salicylic acid does not seem to be an efficacious antiseptic for dairy products, whilst its medicinal effects are more marked than those of boric acid, and similarly saltpetre presents no advantage over this antiseptic.

We are led, therefore, to the conclusion that so long as boric acid is used, and is carefully mixed with the cream in a proportion not exceeding one-quarter per cent., harm is scarcely likely to accrue save under exceptional circumstances, whilst if the use of preservatives were prohibited, cream could only, under the present conditions, be distributed by a daily supply. The question of sterilization with the subsequent exclusion of air has not been much discussed, though there is no obvious reason why this method should not be employed by grocers and others who wish to stock cream for considerable periods.

Possibly after the addition of preservatives to milk has practically ceased—a process which is almost sure to occur either by statute or by frequent successful prosecutions—the introduction of more cleanly methods of milking, and greater facilities for cooling and cold storage, may lead to the spontaneous abolition of antiseptics in cream also.

In any case the declaration of the amount would give medical men an opportunity of studying the effects of small doses of boric acid on the consumer, and if these are found to

[1] Report of Departmental Committee.

be harmful, the necessary steps could be taken to prevent its being employed.

The addition of alkalis, such as sodium bicarbonate and lime, to cream cannot but be prejudicial, as these substances possess little or no antiseptic properties, and only tend to mask fermentative changes, and so lead to a false sense of security.

The only other dairy product in which preservatives are frequently found is butter. They are apparently not present in condensed milk or in ordinary cheese, since in the Government Laboratory 196 samples of cheese and eighty-six samples of condensed milk were examined without detecting any preservative.

It is probable, however, that had some of the many varieties of cream cheese been examined, preservatives would have been found.

Butter.—The process of butter-making is an example of the decomposition of some of the constituents of cream by bacterial agency. The flavour of a sample of butter is entirely due to these products of decomposition, and it has been conclusively proved that objectionable qualities, such as that occurring in 'turnipy' butter, are due not to the pasturage, but to a special micro-organism which has found its way into the cream, and set up a form of decomposition leading to the production of a taint. A very large amount of work in connection with the bacteria concerned in the ripening of butter and other dairy products has been done in Denmark and America, and the micro-organisms concerned in the production of the most appreciated flavours have been isolated in the laboratory, and they can now be purchased by farmers. They are technically known as 'starters.' As cream taken from the cow contains innumerable species of micro-organisms, some favourable and others unfavourable to the production of high-class butter, it is obvious that theoretically the best way of producing such butter is to kill off all the organisms present in the cream, and then add the necessary starter. This is actually done in Denmark with the most favourable results. The cream is first pasteurized,

and then a certain quantity of milk in which the laboratory starter has been allowed to propagate is added, and the whole kept at the temperature found to be most favourable to the growth of the organisms. The best results are said to be obtained when the cream has been pasteurized at about 90° C., a higher temperature than that ordinarily employed.

In 1891 only about 4 per cent. of the butter exhibited at the Danish butter exhibitions was made from pasteurized cream with a pure starter, but in 1895 no less than 86 per cent. of the butter had been so produced, and obtained the prizes awarded for first-class butter.

Butter as made in the way usually adopted in England is liable to contain as abundant a bacterial flora as milk. In the centrifugalizing process for the separation of the cream some of the bacteria are driven out with the milk, and the remainder are carried down with the cream, whilst chances of further pollution occur during the churning and packing. In the centre of a pat of butter 2,465,555 micro-organisms have been found in a gramme (15·5 grains), and as many as 47,250,000 on the outside. Although pure butter fat is not so good a culture medium for bacteria as milk, yet a certain amount of buttermilk is usually left in the process, and provides a suitable pabulum for putrefactive organisms.

From a consideration of these facts it will be gathered that some method must be adopted to exclude such organisms or to inhibit their growth, especially as butter requires to be kept for some weeks before it reaches the consumer. These methods comprise pasteurization, refrigeration, and the addition of antiseptics.

A considerable proportion—according to some observers as much as half—of the butter sold in England comes from Denmark, and is free from preservatives other than a small quantity of common salt. The remainder, excepting such as is produced locally, is chiefly derived from Ireland, France, and the Colonies, and most of this contains an antiseptic, almost exclusively consisting of boric acid or borax; usually

in conjunction with a small quantity of salt or saltpetre. Formaldehyde is also occasionally used. The reason for this difference lies largely in the fact that, whilst butter-making takes place throughout the year in Denmark, it is limited in other countries to certain months of the year, chiefly April to November, on account of the expense of winter dairying. Consequently, whilst Danish butter is consigned once or twice a week throughout the year and is quickly consumed, that from other countries may require to be stored for many months. A possible further factor may lie in the fact that Danish butter is, as has already been stated, made largely from pasteurized cream with the assistance of pure starters, whereby the entrance of organisms concerned in the production of rancidity and other deleterious changes is hindered.

The following table, taken from the Report of the Departmental Committee, shows the percentage of samples which were found by different observers to contain boron compounds:

Authority	Percentage preservatized	District
Government Laboratory .	57·1	Home and abroad
Mr. L. K. Boseley . .	50·0	London
Dr. Walford . . .	44·5	Cardiff
Dr. Hill	35·0	Birmingham
Dr. Williams . . .	35·1	Glamorgan

The percentage of preservatized butters at different seasons is not liable to such variations as occurs in the case of milk; in fact, since the local manufacture takes place chiefly during the warmer months, the prevalence of antiseptics is likely to be greater during the winter, when a quantity of preservatized samples come into the market. As an illustration of this, the percentage of samples of butter found to contain preservatives in Birmingham was thirty-one from October to March, as against twenty-three from April to September, during the period July 1896 to September 1899.[1]

[1] Dr. Hill, Report of Departmental Committee.

Whilst, as will be mentioned later, many of those connected with the butter trade in Ireland, New Zealand, and elsewhere consider that preservatives are unnecessary, others who advocate their use are generally agreed that one-half per cent. of boric acid (35 grains per pound) is sufficient for all practical purposes.

The following quantities have, however, been found in samples taken for analysis by different observers:

Authority	Maximum		Minimum	
	Percentage	Grains per lb.	Percentage	Grains per lb.
Dr. W. Williams	1·600	112	0·014	1·0
Dr. Bernard Dyer	1·350	94·5	0·030	2·1
Dr. J. H. Jones	1·300	91·0	0·710	49·7
Dr. E. Walford	1·020	71·4	—	—
Mr. W. W. Fisher	1·000	70·0	0·250	17·5
Government Laboratory	0·935	65·5	0·477	33·4
Mr. W. C. Williams	0·885	62·0	0·015	1·1
Mr. W. F. Lowe	0·714	50·0	0·100	7·0
Mr. H. D. Richmond	0·705	49·3	—	—

The export butter trade is largely in the hands of companies, having depots fed by neighbouring farms These depots consist either of 'creameries' as in Denmark, or 'factories' as in France. In Ireland both exist. At the creameries the milk or cream is received from farmers and made into butter, whilst at the factories the butter arrives as such from the farms and is blended at the central depot. It is obvious that in either case there is an opportunity for a double addition of antiseptic. Usually the preservative is added in weighed quantities during the making or blending respectively, and there should, therefore, be no difficulty in limiting the amount present.

In some cases, however, it appears that French and Australian butter is made without the addition of an antiseptic (other than salt), and is covered with cloths which have been wrung out of boric acid.[1] A certain amount of the

[1] Mr. Wheeler Bennett, Report of Departmental Committee.

antiseptic is found in the interior of the sample in such instances.

As in the case of milk and cream, the quantity of boric acid recommended for use by the manufacturers of patent preparations varies considerably. If the directions accompanying 'Ramsden's Milk Preserver' are carried out, the butter will contain 125 grains of boric acid per pound. This preparation is described as being 'Totally harmless to the most delicate child.' In the case of a similar mixture a quantity corresponding to 114·5 grains per pound (1·637 per cent.) of boric acid is recommended, whilst 1 per cent. is a usual proportion.[1]

At one Irish creamery visited by members of the Departmental Committee, pure boric acid is mixed with common salt, and added by the dairymaid in the nominal proportion of three handfuls to 56 lbs. of butter. The dairymaid stated that she was able to estimate the amount required in this manner, and did not, therefore, weigh the preservative. On investigation it was found that the handfuls varied from 1½ to 1¾ lbs., whilst she was also not able to gauge the amount of butter at all exactly.

Formaldehyde is comparatively little used for the preservation of butter; if employed the sample is usually allowed to steep for half to one hour in a solution of varying strength, and the liquid is then worked out.

Saltpetre is occasionally employed alone, but more usually in conjunction with boron preparations or common salt. Larger quantities are necessary than in the case of boric acid, about a quarter of an ounce to the pound of butter being sometimes employed.

Common salt is not often used alone as a preservative, since the quantity necessary for this purpose (10 per cent. or even more) would not now be tolerated. In most parts of England butter containing a small proportion, from ½ to 2 or 3 per cent. (35 to 210 grains per pound), is preferred to an entirely

[1] Report of Departmental Committee.

saltless article, and possibly even this may assist in preventing rancidity.

Boron preparations appear to be especially well adapted for preserving butter, and if any antiseptic is needed at all, they will probably be less harmful than formaldehyde, salicylic acid, or saltpetre. One-half per cent. is, as has already been mentioned, sufficient for all practical purposes, and with this amount there is little likelihood of evil consequences, especially as the consideration with regard to infants and invalids mentioned under the sections on milk and cream hardly applies to butter, so long as the other articles of food consumed are free or almost free from the same chemical; but if this is also present in milk, cream, ham, bacon, fresh meat, and various other articles of common consumption for which boron compounds are used, even a healthy adult may obtain an overdose. It is therefore of importance that if the addition of preservatives is to be allowed, the quantity should be strictly limited even in butter.

With the danger referred to above, it is desirable that the use of preservatives should be reserved chiefly for those foods for which they are practically indispensable, and in spite of the opinions of many, it is doubtful if butter comes under this category, since none of the butter from Denmark contains any preservative (beyond common salt); and in reply to circulars sent out to a number of large butter establishments in New Zealand, 60 per cent. stated that they had found preservatives unnecessary, 20 per cent. were undecided, or declined to express an opinion, whilst the remainder, including, it is true, some of the largest exporters, considered that they were necessary. Moreover, formerly at all events, two-thirds of the samples which left New Zealand were free from preservatives.[1]

Preservatives are rare in Canadian butter,[2] whilst at one of the Cork creameries it has been found that butter made from pasteurized cream, with the aid of a starter, will keep two or

[1] Mr. Carl W. Sorensen, Report of Departmental Committee.

[2] Mr. James Riley, *ibid.*

three weeks with one-half per cent., and two to three months with 3 per cent. of salt.[1]

To ensure a supply of butter free from preservatives several things are essential. The manufacture must be conducted with care and cleanliness, the use of pasteurized cream and a starter is advisable, the process must be carried on throughout the greater part of the year, or failing this cold storage must be provided, and better means must be adopted for the carriage of the butter on railways than at present exists.

As regards the use of pasteurized cream, many connected with the butter trade consider that the flavour is thereby spoilt, but the reverse opinion is held by others equally well qualified to judge. From a theoretical point of view it is difficult to imagine why the flavour, which is due to microbial activity, should be inferior when the proper organisms are introduced alone, to that produced when they obtain access in a haphazard manner, in company with innumerable other organisms of doubtful influence as regards their action on the cream. There is not the shadow of doubt that objectionable flavours are due, not as has been erroneously supposed to the pasture, but to particular species of organisms which can be excluded by pasteurization, and in more than one instance in Denmark a district with a reputation for poor butter has been able by biological means to improve the quality; moreover, the chief prizes at the exhibitions have been obtained by butter made from pasteurized cream.

In order that unpreservatized butter may keep, it is also necessary that as much as possible of the buttermilk shall be squeezed out, and that the percentage of water shall be kept as low as possible. With reference to the influence of buttermilk on the keeping qualities an interesting piece of evidence was given by Mr. Brierley to the Departmental Committee. Two jars of butter were received simultaneously from the same farm. One of the jars was broken during transit, and it was

[1] Report of Departmental Committee.

necessary to wash the butter and re-work it, by which process most of the retained buttermilk was removed. This butter remained sweet, whereas the butter in the second jar when opened was in such a state of decomposition that it could not be used.

Reference was made in discussing milk to the unsatisfactory conditions under which railway transport takes place on many of the lines, and the same is equally true in the case of butter. Not only is there a lack of special wagons properly constructed so as to keep their contents as cool as possible, but the butter is frequently badly handled, exposed to the sun, or packed in dirty vans used at other times for fish or cattle, whilst, owing to the heavy freightage charged on passenger trains by some lines, it must be consigned by slow goods trains.

Fortunately, however, these conditions are not universal: the Great Southern and Western Railway Company in Ireland are building wagons fitted with ice-receptacles, and provided with double sides and roofs, whilst the floors are to be lined with felt and contain an air space. Moreover, a special night train is run during the summer to catch the steamer at Holyhead.

The Great Central, Great Western, and London and North-Western Companies provide special vans for large consignments, which in the case of the first-named line are conveyed by special trains. The Great Western Company provide wagons with ice-receptacles in some cases. No special provision is made on most of the other English lines.[1]

The vessels conveying butter from Denmark, and also some of the steamers of the Cork Steam Packet Company, are furnished with refrigerating chambers for the carriage of butter.[2]

Looking at the whole question from the point of view of the sanitarian, one cannot but express a wish that the use of preservatives in butter should be declared illegal, since there is no evidence to show that the trade could not be conducted without this addition if the precautions already mentioned

[1] Report of Departmental Committee. [2] *Ibid.*

were adopted, as the unnecessary and repeated introduction of a substance normally foreign to the body cannot be deemed desirable from a physiological point of view.

If prohibition were to entail pasteurization of the cream, there would be a further gain in the interests of the public health in the diminished risk of the transmission of infectious diseases, to say nothing of the poisons such as tyro-toxicon and allied products of decomposition, which dangers undoubtedly exist at present.

On the other hand, there is a strong probability that there would be a considerable quantity of rancid butter in the market during hot weather, until the necessary organization had been perfected, whilst the Irish and Colonial butter trade would undoubtedly suffer, unless, as suggested by some of the witnesses examined by the Departmental Committee, a period of two or three years were allowed to elapse before the addition of preservatives was declared illegal. Pasteurization of the cream would probably prove to be essential, in which case the factory system would require considerable modification.

By making the declaration of the preservative and of its amount compulsory, an opportunity would be given to the householder of refusing to purchase butter thus treated. This, however, was not among the recommendations of the Departmental Committee.

Failing complete prohibition, as comparatively small quantities of boron compounds are quite sufficient for all practical purposes, there is no reason for permitting the use of any substance other than salt for flavouring.

Margarine.—This substance is even more frequently preservatized than butter, the antiseptic commonly employed, apart from salt, being boric acid or borax. In Liverpool nearly all the samples contained boron compounds, whilst the percentage found to be thus treated in Birmingham was 84, and in samples from various sources analyzed at the Government Laboratory 77·4.[1]

[1] Report of Departmental Committee.

The reason for the frequent use of antiseptics is probably the fact that margarine is usually churned with milk, whereby a readily decomposable substance is introduced, together with the organisms capable of producing such changes. The manager of one of the large Irish creameries stated before the Departmental Committee that, although he used no boron preservatives for his butter, he had found it necessary to add one half per cent. of boric acid to all the margarine manufactured.

On the other hand the margarine imported from Holland is not made with milk, and no preservatives are added; nevertheless it keeps fresh for a month.

Expressed as boric acid, samples of margarine have been found to contain 1·1 per cent. (77 grains per lb.) by Dr. Hill, and 1·05 per cent. (73·5 grains per lb.) at the Government Laboratory.[1]

As regards the advisability of permitting the use of preservatives, the same considerations apply as in the case of butter.

[1] Report of Departmental Committee.

CHAPTER XI

ALCOHOLIC BEVERAGES

The formation of alcohol and of some of the flavouring essences of alcoholic beverages is dependent on fermentative changes set up by the action of micro-organisms, chiefly yeasts. Usually a mixed culture of these yeasts is added to the sugar, which is the basis of the alcohol and ethers, whereby micro-organisms are frequently introduced which are either useless or produce unpleasant flavours, giving rise, in the case of beer to 'sick' beers. Several such organisms, known in some cases as 'wild yeasts,' have been isolated, and certain brewers therefore only employ cultures of organisms capable of producing useful products. These are analogous to the 'starters' used in butter-making, but there is scope for much further investigation to put the matter on a firm scientific basis.

A pure alcohol-producing yeast will convert sugar into alcohol and carbonic acid until the alcoholic strength reaches about 13 to 14 per cent., after which time the action ceases. It can, of course, be checked by pasteurization at any earlier stage according to the strength of alcohol required. Other organisms are capable of oxidizing the alcohol into aldehyde and acetic acids, the latter substance giving rise to sourness. Usually, minute quantities of aldehyde and esters are also produced during the fermentation, which are responsible for the flavour or bouquet of the fermented liquid.

Beer and Cider.—It is evident, therefore, that with beverages of low alcoholic strength such as beer and cider it is necessary to check the fermentation at an early stage, and also to prevent the growth of organisms which are concerned in producing sourness and the diseases referred to above.

If a 'still' beer or cider is required, fermentation can be stopped by pasteurization, filtration, or the addition of antiseptics. In bottled beer and cider fermentation is allowed to proceed, whereby the liquid becomes so charged with carbonic acid gas that further fermentation is prevented. Another method occasionally employed is to pasteurize the liquid and then charge it artificially with carbonic acid, but the resulting flavour is generally inferior. If a mixed yeast is used for brewing there should be a great preponderance of the useful varieties, in order that the proper degree of fermentation shall have been arrived at before the wild yeasts have time to act. Theoretically, there is an obvious advantage in employing pure yeast cultures, and this is frequently done in the case of beer, and, no doubt, could be done in that of cider.

Nevertheless, there seems to be a growing tendency to add antiseptics to beer, chiefly salicylic acid or the sulphites (generally in the form of bisulphites of lime). Boric acid, benzoic acid, saccharin, and the fluorides are also occasionally used.

According to Dr. Schidrowitz, who gave evidence before the Beer Materials Committee in 1898, the addition of these preservatives has been largely brought about by the increase of competition in the brewing trade, and the considerable sums which brewers are compelled to expend on tied houses. As a result an increased amount of beer must be turned out by the same plant, necessitating a very considerable reduction in the brewing time and the gravity of the beer brewed, and it is difficult to produce a good keeping beer without the use of preservatives.

Out of 100 samples of imported beer examined in the Government Laboratory nineteen contained salicylic acid and twenty sulphites, a percentage of thirty-nine.[1] What proportion of beers brewed in this country contain preservatives does not appear to have been recorded.

The smallest amount of salicylic acid which is sufficient for

[1] Report of Departmental Committee.

keeping beer is probably about 1 in 10,000, or 0·9 grain per pint, and this quantity has been found by Mr. Cassal in a sample of bottled beer. In the Government Laboratory some imported beer contained 3·4 grains per pint.[1] One part of sulphite of lime in 5,000 appears to be necessary for beer (or about 1 grain of sulphur dioxide per pint). Mr. Chapman and Dr. Rideal have found 0·88 and 0·79 grain per pint respectively, whilst a sample of imported beer analyzed at the Government Laboratory contained 1·6 grains per pint.[2]

As far as these analyses go, therefore, it does not appear that the requisite quantities are greatly exceeded, and there is not the same opportunity for the repeated addition of preservatives that exists in the case of milk.

Although beer is frequently consumed in far larger quantities than milk, there are not the same objections to the use of preservatives in the former as in the latter, since it is not used in quantities by infants, young children and invalids.

With anything like a moderate consumption of beer there is little fear that a harmful dose of either of these antiseptics will be taken, and little objection can be raised to their use so long as they are not added in excess, or in order to mask deficiencies in the malting or brewing, even though they may not be indispensable. Additions are apparently sometimes made to disguise inferiority of quality, and saccharin is sold as a 'cure' for 'sick' beers.[3]

Probably the sulphites are less likely to be harmful than salicylic acid, as a certain portion will, except in the case of bottled beers, be converted into inert sulphates by the time they reach the consumer.

As regards salicylic acid, the recommendation of the Committee that the amount should be limited to 1 grain per

[1] Report of Departmental Committee. [2] *Ibid.*

[3] At a meeting of the Departmental Committee the following extract from a prospectus was read: 'As a cure for sick beers.—Even when such a dubious lot of beer already begins to show signs of incipient "taint," there may yet be time to save it by quick action in introducing, as may be needed, from 1 to 2 ounces of saccharin per 500 gallons, and thereby arresting the souring process, and at once making the beer drinkable and marketable.'

pint, and its presence declared, would meet all possible objections.

Similar preservatives are used by many cider-makers to keep the cider clear, and to prevent the conversion of all the sugar into alcohol.

Amongst the trade preparations may be mentioned 'Sugar of Boron'; 'Cynin,' consisting of salicylic acid, borax and glycerine; 'Walter Gregory's Powder,' containing salicylic acid and red oxide of iron; 'Hawke's Anti-ferment'; and 'Cider Pasteur.'[1]

The last contains calcium sulphite, and, according to testimonials,[1] it is able to restore cider when the latter is rendered apparently worthless by the action of wild yeasts.

The quantity of these antiseptics recommended is about 2 to 5 grains a gallon, and, in the case of saccharin, about half a grain a gallon. Such amounts can hardly do any harm, but, as in the case of beer, their presence may be an indication that due care has not been taken in the manufacture.

One large firm of cider-makers,[2] who turn out 15,000 to 20,000 gallons a year, find no difficulty in dispensing with preservatives. Only sound fruit is used, and after fermentation the cider is filtered. In addition to scrupulous cleanliness, the only precaution which is found necessary is to burn sulphur in some of the vessels which are intended to receive the filtered cider, and even this is not always done.

There is no doubt that preservatives are not necessary either in beer or cider if the liquor is properly brewed from sound materials. The detection of preservatives in these beverages, therefore, indicates inferiority of quality, to say the least, and there is little doubt that had the brewing interest been less powerful the use of salicylic acid would have been condemned.

Wines.—When either a considerable quantity of alcohol or only a small amount of sugar is present in 'still' wines these

[1] Report of Departmental Committee.

[2] Mr. Radcliffe-Cooke, Report of Departmental Committee.

are not very liable to undergo secondary fermentation, since in the former case the amount of alcohol will serve to prevent further action, and in the latter the saccharine solution will be too dilute to undergo this change.

Preservatives, other than possibly a little alcohol in the form of brandy, are therefore seldom added, whilst in the case of sparkling wines undue fermentation is kept in check by the carbonic acid produced. Mr. Cassal has, however, detected salicylic acid in port to the extent of 0·4 grain per pint, and in sherry to the extent of 0·2 grain per pint.[1] These small quantities were possibly introduced by the blending of a rich and a poor sample, the latter containing the preservative.

No properly made wine requires the addition of an antiseptic, and none, with the exception of common salt up to 1 gramme per litre, is allowed in France, the chief wine-producing country of the world.[2]

The 'plastering' of wine comes under a different category, being employed chiefly for cleaning purposes, though its use is somewhat analogous to the use of alkalis in milk and cider.

Mr. Alfred Gilbey, of the firm of Messrs. W. & A. Gilbey, the celebrated wine merchants, said in his evidence before the Departmental Committee that he had never heard of an imported wine containing any preservative, except brandy, or any foreign colouring matter. The wines of low alcoholic strength are not shipped to this country as they 'would not stand the journey.' The process of wine-making as described by him is as follows:—The fully ripe grapes are separated from the stalk and placed in a vat. The broken-up grapes and juice speedily commence to ferment when the skins and pips float on the top. The wine is drawn off in about ten days into hogsheads, where the fermentation goes on for another nine months, after which it is placed in cellars, and kept there until three years old, when it is bottled and sent to this country, and sold at prices varying from 1*s.* per bottle upwards. With slight variations all light wines are made in this way. He is of

[1] Report of Departmental Committee. [2] *Ibid.*

opinion that the light wines sold at the above-mentioned price are as pure and wholesome as the most expensive wines, and he knows of no reason why they should not be, the juice of the grape being so cheap and plentiful. There is no difficulty in keeping such wine, and the addition of any preservative is therefore totally unnecessary.

The case is very different as regards English wines, which frequently contain considerable quantities of preservatives, chiefly salicylic acid, benzoic acid, sulphites, and formaldehyde.

Salicylic acid has been found in raspberry, ginger, and black-currant wines in quantities varying from 3·3 to 19·2 grains per pint, whilst calcium sulphite appears to be added in varying proportions, the wine being kept until all smell of sulphur dioxide has disappeared.[1]

Although small quantities of these antiseptics are not likely to do harm, some limit should be fixed, as otherwise inordinate amounts may be used. British wines are of low alcoholic strength and usually rich in sugar, hence they are very prone to ferment. Makers have no control over the way in which they are stored after reaching the retailer, and they may be kept for long periods and exposed in warm stores. Should fermentation take place the reputation of the maker suffers, hence the temptation to put in sufficient preservative to prevent decomposition under any condition of storage. These wines are never drunk in any quantity or taken systematically for long periods like foreign wines and beers, hence there is much less risk of harm ensuing from the use of reasonable quantities of preservatives.

Mr. A. Gilbey is in error in supposing that very light wines are not shipped to England, as such wines made from grape must are largely used as a basis for British wines, fruit juices or flavouring essences and colouring matter being added according to the character of the wine desired. Such wines are perfectly wholesome, but do not correspond with home-made wines, and

[1] Report of Departmental Committee.

the terms 'British' and 'home-made' are not therefore synonymous.

The Departmental Committee expressed the following opinion :—'As regards wine, whether British or imported, we are of opinion that wine which cannot be kept without the use of preservatives had better not be offered for sale.' Doubtless this was based on evidence given to the effect that such wines can be made to keep without the addition of preservatives. Whether such is the case or not, the fact remains that most British wines do contain small quantities of preservatives, and makers of the highest repute assert that, unless some preservative is added, complaints are constantly received as to the keeping quality of the wines.

Medicated wines have also been found to contain preservatives. These are usually taken in very small quantities and for limited periods, but, notwithstanding, such addition appears to us to be objectionable. The so-called medicated wines, sold at a cheap rate and containing quinine, or quinine and iron, or extract of meat, are often of very inferior quality, and preserved by the addition of salicylic or boric acid. These may be taken by invalids for considerable periods, hence the presence of preservatives therein is particularly objectionable.

CHAPTER XII

TEMPERANCE BEVERAGES

THE word 'temperance' rather than 'non-alcoholic' is used because, in such beverages as are of the sparkling variety, the dissolved carbonic acid gas is, in some cases, derived from the fermentation of sugar by a yeast, and a small amount of alcohol is therefore simultaneously formed. Some specimens of ginger beer, for instance, may contain as much as 3 per cent. of alcohol, whilst in herb beers the percentage may be less than one-half per cent., although it has been known to rise as high as 10 per cent.

Many of these beverages, however, are free from alcohol, and where sugar is present atmospheric germs may gain access, and set up fermentative changes. Hence it is necessary to take steps either to check excessive fermentation or to prevent it entirely as the case may be, and this may be done by sterilization, pasteurization, filtration, or the addition of antiseptics. As regards the bottled beverages, alcoholic fermentation will be partly checked by the alcohol and carbonic acid gas formed.

Carbon dioxide or carbonic acid gas is the gas used for aerating soda water, seltzer water, lemonade, ginger ale, &c., and appears to have marked anti-fermentative properties, though it is not usually classed as an antiseptic. Beverages, which have been well aerated with this gas and efficiently stoppered, rarely, if ever, ferment or undergo any change due to the action of bacteria, and as a matter of fact such liquids if examined a few days after preparation are usually found to be sterile. No doubt excessive indulgence in such aerated

beverages may cause inconvenience from their inflating properties, but there has never been any occasion to think that the carbonic acid gas is harmful; hence there cannot be the slightest objection to its use. These beverages are usually made by putting into each bottle or syphon a definite quantity of saline solution or of syrup, and filling up with aerated water. The syrups and solutions used are prone to change; hence it is not unusual for them to contain preservative, and when such is the case the beverages prepared therefrom will contain preservatives. Imported syrup and fruit juices frequently contain salicylic or sulphurous acids, and are largely used for making beverages.

In non-aerated beverages preservatives are frequently found. They have to be prepared in such a manner that the retailer may store them an indefinite period, and expose them in his windows; and after sale the purchaser expects the contents of the bottle to keep fresh and sweet until all is consumed. Under such conditions it is surprising that more makers do not use antiseptics, and we are opinion that such are used to a larger extent than is usually supposed. Certain antiseptics are rarely sought for, and their presence is consequently overlooked.

Out of 596 samples of temperance drinks examined at the Government Laboratory, preservatives were found in 115, or 19·3 per cent. Salicylic acid was detected in sixty-four, boric acid in twenty-two, sulphites in nineteen, formalin in three, and a mixture of boric acid and salicylic acid in seven of the samples.

Out of 103 specimens classified as 'Temperance Wines and Cordials,' preservatives were found in no less than eighty-six, or 83·5 per cent. In fifty-three cases the antiseptic was salicylic acid, in six sulphites, and in the remaining twenty-seven a mixture of salicylic acid and sulphites.[1]

Sulphurous acid is largely used for certain fruit juices and cordials. Benzoic acid is also probably used, but there is apparently no record of its presence being detected. The

[1] Report of Departmental Committee.

amount introduced will depend upon the nature of the beverage, the length of time it may be in the hands of the retailer, and whether the whole contents of a bottle are likely to be consumed at once or to last for several days. Where the whole contents are consumed at once there is no need for an antiseptic, as, if the liquid is sterilized and bottled with proper precautions, it should keep an indefinite period. If, on the other hand, it is only used in small quantities at a time, it is difficult to see how it can be kept sweet without the addition of some preservative.

Boric acid has been found in herb beers up to 7·3 grains per pint, and salicylic acid up to 8·1 grains per pint. In lime juice Mr. W. C. Williams has found 13·5 and Mr. Cassal 8·7 grains of salicylic acid per pint. In temperance wines and cordials salicylic acid has been detected in quantities up to 19 grains per pint, sulphites up to 4·5 grains of sulphur dioxide per pint, and formalin to the extent of 1 part in 25,000.[1]

Very much smaller amounts of these preservatives have been estimated in other samples which have kept equally well, and as considerable quantities of some of these beverages may be consumed by children as well as adults, it is desirable that a limit should be fixed and the presence of the preservatives declared.

The suggestion of the Departmental Committee that the amount of salicylic acid permissible should be restricted to 1 grain per pint is not likely to be adopted. It may be a proper quantity to fix for beers and beverages imbibed by the pint, but is too small to be of any service in syrups and concentrated essences used by the spoonful. In such beverages a larger proportion might reasonably be permitted.

The objections urged against the use of antiseptics in milk do not apply in the case of temperance beverages, since they are not used as foods, nor are they articles of real necessity, but luxuries. Neither are they largely used by invalids or very young children, and if consumed in considerable quantities,

[1] Report of Departmental Committee.

the sugar and acids, so generally present, are far more likely to cause derangement of the digestive functions than are the preservatives employed. Considering, however, that they are used most largely during the hot weather—that is, at the time when preserved foods are more abundantly consumed, and when larger quantities than usual are likely to be found in dairy produce—it is obvious that any danger arising from the antiseptics is likely to be accentuated by the employment of such beverages; hence the desirability of reducing the amount used to the minimum, and of declaring the nature of the preservative present. The declaration cannot, of course, be hoped for unless rendered compulsory by law, as one maker is not likely to inform the public that he uses preservatives when his rivals do not. Were he to do so he would create a prejudice against the goods of his own manufacture, which might contain less preservatives and be in other respects more wholesome than the products of his rivals who make no declaration. Hence such declaration, if only partially adopted, might be harmful rather than beneficial to the general public.

In aerated beverages, and in beverages intended to be consumed as soon as the bottles are opened, there is no real need for the use of antiseptics, and these are the beverages imbibed in the largest quantities. In concentrated liquors, syrups, cordials, and fruit juices, the use of suitable antiseptics in proper proportions may be permitted, as it is in the highest degree improbable that, in the dilute condition in which they are used, any harm will result.

CHAPTER XIII

FRUITS, JAMS, AND VEGETABLES

As a rule fruits are very prone to change, especially if at all damaged, but no preservatives should be necessary to keep the fresh article a reasonable length of time. If the fruit is in such a condition that it will not keep without their use, it is almost certainly unfit for sale. Nevertheless formic aldehyde is occasionally sprayed on the surface of fruit to improve its keeping properties.

In the case of bottled or tinned fruit and jams some method of preservation is essential, since a sample must be capable of storage for many months or even years. This can be effected by sterilization and exclusion of air, a method usually adopted in the case of whole fruits, though the colour and taste may suffer somewhat. Sulphurous acid or sulphites are occasionally added to bottled fruit, two samples out of forty-eight examined in the Government Laboratory being found to contain sulphites.[1]

Sterilization by heat is employed for jams ; the sugar added, however, may be regarded to some extent as a preservative.

There is no doubt that with proper care jams can be made to keep for an indefinite period without the aid of preservatives.

On the other hand a considerable proportion of jam-makers add antiseptics, chiefly salicylic acid, benzoic acid, or sulphites, and no doubt, if the fruit is not in a good condition, and if cleanliness is not observed, it is difficult to ensure the keeping qualities of jams without their use. Mr. Lowe detected their presence in half the samples which he examined, and Dr. Hill in five out of six.[2]

[1] Report of Departmental Committee. [2] *Ibid.*

It is claimed by those who advocate their use that the flavour of the fruit is partly lost by the prolonged boiling which is essential if preservatives are not added, whilst the jam also becomes thick and gluey, the sugar frequently crystallizing at the top. A more practical advantage gained by using antiseptics is that the jam so made will keep with about 6 per cent. more water in it than will an unpreservatized sample, and this represents 6 per cent. extra profit.

The following quantities of salicylic acid have been found in samples of jam by different observers: [1]

Authority	Salicylic acid	
	Per cent.	Grains per lb.
Government Laboratory	0·121	8·5
Mr. W. C. Williams	0·064	4·5
Mr. W. F. Lowe	0·060	4·2
Dr. Voelcker	0·050	3·5
Dr. Bernard Dyer	0·007	0·5

The usual quantity employed by jam-makers is half an ounce to a hundredweight, or about 2 grains per pound.

If preservatives are added in the small proportions indicated above no injury to health is likely to occur, but there seems to be no absolute necessity for their use, and it possibly encourages the employment of unsound fruit. Apricot jam, being made from the imported fruit pulp, is more difficult to manufacture without preservatives, since the pulp may often contain them, but it is quite possible to keep fruit pulp in stock tins or casks which have been fumigated with sulphur dioxide, if the pulp is first sterilized by boiling.

Fruit pulp imported from the Continent is received in casks, which when opened smell strongly of sulphurous acid. The amount of this preservative in the pulp appears to be very small and may be harmless. It is practically impossible to determine in such pulp what proportion of the fruit was rotten or in the early stage of decomposition, though a micro-

[1] Report of Departmental Committee.

scopic examination may give some indication of the condition of the fruit at the time of packing. Many kinds of fruit, especially grapes and plums, can be successfully preserved by desiccation.

Vegetables may be preserved by the exclusion of air, by desiccation, or by the addition of antiseptics, salt, saltpetre, or vinegar being chiefly used. As the last-named substance may contain sulphites, formic aldehyde, boric acid, or sulphuric acid, one of these may also be present in the pickle.

The addition of copper to green vegetables is with the view of preserving the colour rather than to prevent fermentative changes, and this substance therefore hardly comes under the category of food preservatives.

Vinegar has been found to contain 1·75 grain per pint of boric acid, 0·5 grain per pint of sulphur dioxide, and 2·5 grains per pint of formalin.[1] These small quantities should be harmless, but they are quite unnecessary.

Sauces and ketchups occasionally contain antiseptics other than salt, salicylic acid, sulphites, or benzoic acid being employed. These liquids have to be prepared so as to keep an indefinite period, and are only used in comparatively small quantities at a time, so that no harm whatever need be apprehended from the addition of reasonable amounts of preservatives thereto.

[1] Report of Departmental Committee.

CHAPTER XIV

MEAT, GAME, EGGS, AND FISH

MEAT foods are less liable to undergo rapid decomposition than dairy products, since the opportunities for bacterial pollution are usually fewer, and such organisms as gain access are only able to act on the outside of the carcass or joint.

Nevertheless, during hot weather steps must be taken in the case of fresh meat to prevent decomposition whilst the meat is hung, and such measures are still more necessary in the case of ham, bacon, &c., which are not intended for immediate consumption.

The methods adopted for different kinds of meat foods consist in refrigerating, sterilizing with subsequent exclusion of air, the addition of chemical preservatives, smoking, and drying, or combinations of these processes.

The process of refrigerating calls for no comment. Cold storage is becoming more and more common in the large towns, to the great advantage of the butcher and the public. Such an establishment should always be attached to a public abattoir.

The exclusion of air if properly carried out is satisfactory when the food has first been completely sterilized. There is, however, the risk of metallic contamination if tins are employed: danger from this source is discussed elsewhere.

Salting and pickling is carried out in four different ways: (1) salt is rubbed into the pieces of meat in a dry condition; (2) the meat is soaked in brine; (3) the brine is injected by means of a syringe into the connective tissue lying between the bone and muscle; and (4) the pickling solution may be pumped into the aorta, and so, by means of the arterial system, into the

substance of the meat. The last process is said to be complete in three or four minutes.

Salt alone may be used, but usually a proportion of saltpetre is added. Alum and boracic acid are also frequently employed, and sugar enters into some formulæ for pickling solutions. Common salt apparently acts partly in virtue of its antiseptic properties and partly by the abstraction of moisture. A 5 per cent. solution is said to hinder the growth of obligatory anaerobes, though not that of aerobes, whilst the growth of most bacilli is checked by a 10 per cent. solution. On the other hand brine appears to have little or no effect as a bactericide. Tubercle bacilli in cultures remain virulent after they have been covered with salt for two months, and cocci will thrive in a 15 per cent. solution.

The saltpetre is chiefly added to the pickle to prevent the decolourizing effect of salt on the muscle.

The process of soaking meat in a solution of brine leads to an appreciable loss of nitrogen and phosphorus, certain albuminous bodies passing from the flesh into the pickle, reducing somewhat the nutritive value, and it is well known that the process of pickling renders meat somewhat more difficult to digest. Where the pickling by means of brine has not introduced any large quantity of salt into the meat, it is said to be 'mild' cured, the term having special reference to bacon.

English, Irish, and Danish bacon (using this term to include ham) seldom requires any further preservation, though occasionally during the summer a little boron compound may be dusted on the surface or introduced into the 'pocket' (cavity from which the shoulder blade has been removed) to prevent fly-blow. Calcium sulphite is also used for this purpose.

The change which has taken place during recent years in the public taste with regard to mildness has already been referred to, and, in the case of ham and bacon imported from America, it has therefore been found necessary to pack the 'green' sides in boric acid in order to prevent tainting and

fly-blow during the voyage. A small proportion of the products from these countries is still packed in common salt, but absorption continues during transit, with the result that they are only saleable to that class of people which prefers to have such articles heavily salted.

Although packing is the usual method of employing the boron compounds, they are occasionally mixed with the brine, and injected into the flesh during the process of curing. A recipe, for instance, given some years ago in the 'Grocer' consists of 5 lbs. of the boron preservative, with 45 lbs. of common salt, 4 lbs. of sugar, and 3 of saltpetre, the whole being dissolved in 20 gallons of water.[1] Such a mixture would be forced into the flesh under a pressure of about 56 lbs. to the square inch.

Another mixture recommended is made by the addition to the brine of 10 to 20 per cent. of a preparation containing 92 per cent. of boric acid.[2]

Even when the hams are merely packed in boric acid, a certain quantity is absorbed into the interior, though the main portion is removed by washing and brushing before the ham is cooked or smoked.

Mr. J. M. Harris[3] cut portions of bacon which had thus been treated from the middle of each of three joints close to the bone. In the samples it was found that the quantity of boric acid varied from 0·10 to 0·13 per cent. There was no difficulty in detecting the presence of the same substance in the fat and flesh near the surface.

The same observer also sprinkled borax on a piece of fresh pork, and, after the lapse of a week, the quantity present in the centre was found to be 0·15 per cent.

The importation of bacon has increased enormously during recent years. The value of the exports of ham and bacon from Canada has risen steadily from 280,227 dollars in 1889 to 8,034,616 dollars in 1898. It is not surprising, therefore, that the percentage of samples which have been found to contain

[1] Report of Departmental Committee. [2] *Ibid.* [3] *Ibid.*

boron compounds is large.[1] In the Government Laboratory, out of 130 samples, no less than 120, or 92·3 per cent., had been thus treated, corresponding figures found by Dr. Bernard Dyer and Dr. Hill being 41·2 and 77·8 respectively.[2]

The following are the quantities of boric acid estimated to be present by different observers, though the portions of the joints from which the samples were taken are not mentioned:[3]

Authority	Quantity of boric acid	
	Per cent.	Grains per pound
Dr. Bernard Dyer . . .	0·750	52·5
Government Laboratory . .	0·661	46·3
Dr. Hill	0·400	28·0
Dr. Williams	0·340	23·8
Dr. Tubb-Thomas . . .	0·300	21·0
Mr. H. D. Richmond . .	0·130	9·1

The amount found by Dr. Dyer is probably unnecessarily large, and suggests that the boric acid had been injected together with the brine, and this quantity is possibly capable of exerting some effect upon health, when the weight of ham and bacon consumed daily is taken into consideration, especially as boric acid may also be introduced to an appreciable extent by other articles of food.

When the bacon is packed in the preservative a quantity is used varying from one-quarter to 1 per cent. of the weight of the side, and the smaller proportion is apparently adequate. The pork remains in contact with the preservative for a few weeks, and, according to one authority,[4] 80 per cent. of the latter is removed when the side is washed.

The quantity of common salt in mild bacon varies with different brands, and in different parts of the same sample from under 1 to about 8 per cent.

Mr. Harold Faber[5] estimated the amount of this substance present in samples from different sources, and found that the

[1] Report of Departmental Committee. [2] *Ibid.* [3] *Ibid.*
[4] Mr. J. Wheeler Bennett, Report of Departmental Committee.
[5] Report of Departmental Committee.

percentage in the fat varied from 0·23 to 0·85, in the outside portion of the flesh from 3·75 to 7·27, and in the flesh near the bone from 2·18 to 4·03.

If saltpetre is used alone, the quantities would presumably be somewhat the same.

Many persons connected with the export trade consider that this would be ruined if the use of boron compounds were prohibited, and there appears to be no reason why prohibition should be insisted on if preservatives are used in moderation. From the experimental evidence detailed in a former chapter saltpetre seems to be a less desirable antiseptic, bulk for bulk, than boric acid or borax, and if the sides of bacon are simply packed in the boron compounds, the amount which will be absorbed is so small as to be probably negligible. The considerations which applied in the case of milk and cream to children and invalids no longer hold good when applied to ham and bacon, which are foods used by the robust.

On the other hand, there is some reason for believing that the use of a preservative other than salt is not absolutely essential even for the export trade, since one firm[1] which transmits a very large amount of Wiltshire bacon to India and the Colonies, is able to dispense with its use. They employ a little more salt, and extra drying, the sides are then sown up in canvas and packed in salt. No complaints as to taint or fly-blow are received. If the sides are packed in a green state these consequences are sure to happen.

In any case the custom of injecting the boron preservative is objectionable, since as these substances are foreign to the human body, they should only be introduced in the smallest quantities necessary for practical purposes.

The only alternatives to the use of boron preservatives for imported hams would seem to be either to increase the amount of salt and dry the unsmoked article, or to adopt cold storage. An increase in the amount of salt or saltpetre is undesirable, whilst refrigeration has been unsuccessfully tried by one

[1] Mr. J. M. Harris, Report of Departmental Committee.

firm,[1] and would, in any case, very likely raise the price of the food.

Benzoic acid has been used in Queensland for curing hams, and possibly this may occur elsewhere; as it is a more powerful drug than boric acid there are greater objections to its use.

Among the remaining meat foods for which preservatives, other than salt or saltpetre, are used, fresh meat, sausages, pork pies, and meat extracts may be mentioned.

During the hot weather butchers sometimes sprinkle the carcasses or joints of fresh meat with boron compounds, or brush solutions of formic aldehyde or sulphites over the surface. Although cold storage is preferable, these processes are not likely to be attended with injurious effects on the consumer, unless they are done to mask incipient decomposition. The use of sulphites has been prohibited in Christiania on the ground that, whilst harm may accrue to the purchaser from the presence of the antiseptic, the latter seems to have the property of disguising the early stages of decomposition. Reference was made to this matter when the sulphites were being considered. The boron compounds are probably the least objectionable for this purpose.

Sausages in addition to salt and saltpetre very frequently contain boric acid or borax, and sometimes benzoic acid. The two former were detected in two out of three samples analyzed by Dr. Hill, and in half of those examined in the Government Laboratory.[2]

The quantity found by the different observers varied from 1·14 to 0·45 per cent. (79·8 to 31·5 grains per pound).[3] As sausages are not often a regular article of diet, a quantity not exceeding one half per cent. is unlikely to cause much harm, but with nearly 80 grains per pound, the amount of boric acid consumed in a day in conjunction with that present in other food substances, such as butter and ham, might easily approach the dose necessary to produce unpleasant symptoms in a person liable to be affected by this drug. Moreover, pork

[1] Report of Departmental Committee. [2] *Ibid.* [3] *Ibid.*

should as far as possible be consumed in a fresh state, and storage for any length of time is undesirable. There is no animal whose flesh has more often given rise to localized epidemics of food poisoning than the pig.

Pork pies have also been found to contain frequently boric acid, and similar considerations apply.

Boric and benzoic acids have been detected in potted meats. These should be unnecessary if they are properly prepared and hermetically sealed.

Boric and salicylic acids have been found in meat extracts. As these are frequently used for invalids the presence of such antiseptics is objectionable, and there should be no necessity for their use.

The sulphites are being largely used in the preparation of sausages, and articles of that class, and when present lead to the suspicion that tainted meat has been used in their preparation.

Examples of smoking as a means of preservation are furnished by several hog products such as ham, bacon, and some kinds of sausages, and also by certain forms of tongue.

Drying is chiefly of use as furnishing a ready means of preserving and carrying meat under exceptional circumstances, as in the case of 'biltong,' and there is little doubt that the meat loses a certain amount of its nutritive value during the process, its digestibility being impaired.

Game and poultry are subjected to the same methods of preservation as are adopted for meat, but game is usually kept until incipient decomposition has set in. At this stage poultry would be declared unfit for human consumption, and it is questionable whether the use of 'game' in this condition is not often responsible for the production of nausea and diarrhœa, or of disturbances of the digestive functions. As, however, the purchaser and user know the condition of the flesh, they may be left to take the attendant risks.

Eggs are preserved by immersion in various solutions, lime, salt, water-glass, sulphites and salicylic acid. These substances do not penetrate the shell, hence they are in them-

selves unobjectionable, and so long as the shell contents are sweet the eggs are usable. Occasionally they are preserved by the rubbing of some kind of fat into the shells whilst warm and immediately after being laid, to exclude and prevent the action of air.

Fish is more liable than meat to undergo decomposition, and the products may produce most serious effects. This is notably the case with regard to shell-fish and mackerel. Consequently, if efficient methods of preservation are not adopted, such fish quickly become unfit for consumption.

The methods in use for preservation are practically the same as those employed for meat.

With regard to refrigeration a word of caution is necessary. Where the fish is kept in a cold chamber the changes referred to are not likely to occur, but the common practice of storing it directly in contact with ice may introduce the very micro-organisms necessary to produce decomposition, unless the ice comes from a pure source and is kept free from contamination. As soon as the ice melts the fish is bathed in a watery solution, which may contain filth pregnant with putrefactive bacteria, whose action is favoured by the moisture.

When means of refrigeration are not available antiseptics are sometimes employed for fresh fish during hot weather, the substances used being chiefly boron compounds or formic aldehyde.

Boric acid has been found in herrings, caviare, and potted fish, and sulphites in anchovy paste, whilst salt, saltpetre, and vinegar are commonly employed in pickling fish. The amount of these antiseptics which would be consumed is practically inappreciable so long as they are added in moderate proportions. As much, however, as 95 grains per pound of boric acid has been detected in a sample of potted shrimps.

In this connection it may be mentioned that apparently pyroligneous acid is sometimes ased for curing herrings instead of smoking. Whether this is a desirable procedure or not admits of a difference of opinion; possibly the acid is as harmless as the empyreumatic products in the smoke.

PART III

CHAPTER XV

COLOURING MATTERS USED IN FOOD AND DRINK

The employment of pigments for the purpose of colouring articles of food dates back at least fifty years, and was the subject of many investigations by the proprietors of the 'Lancet' in 1851 and subsequent years. Cayenne pepper was found to contain sulphide of mercury, red lead, and various oxides of iron, no less than twenty-two out of twenty-eight samples containing mineral colouring matters; twenty-seven out of thirty-three samples of preserved bottled fruits and vegetables were coloured with copper; red lead was found in anchovies; whilst various specimens of confectionery were shown to contain chromate of lead, gamboge, red lead, sulphide of mercury, umber and sienna, Prussian blue, carbonate of copper, and arsenite of copper; and white lead was detected in ornaments used for adorning cakes. Of the vegetable matters turmeric was used for colouring milk even in 1851.

With the advent of the aniline dyes mineral pigments have almost entirely ceased to be employed, with the exception of copper sulphate and oxides of iron, the former being practically the sole substance used for preserving the colour of green vegetables, none of the more recently discovered dyes being capable of producing the desired effect. Annatto, and turmeric also, are to some extent being similarly replaced.

The colouring matters principally employed may be classified according to their nature into animal, vegetable, and mineral, the chief representative of the first group being cochineal, which is used in jams, jellies, syrups, cordials, and certain preserved fruits such as cherries.

The extent to which artificial colouring matters are to be found in articles of food is indicated by the following table, which is taken from the Report of the Departmental Committee:

SUMMARY OF SAMPLES OF FOOD (BOTH HOME AND IMPORTED PRODUCE) AND THE COLOURING MATTERS FOUND THEREIN (EXAMINED IN THE GOVERNMENT LABORATORY)

No.	Description	Total samples	Colouring matters				Total containing colouring matters	Percentage coloured
			Coal-tar	Vegetable	Animal	Mineral		
1	Milk	296	—	3	—	—	3	1·0
2	Cream	290	9	1	—	—	10	3·4
3	Butter	364	40	87	—	—	127	34·9
4	Margarine	133	100	15	—	—	109[1]	81·9
5	Cheese	196	5	107	—	—	111[2]	56·6
6	Condensed milk	86	—	—	—	—	—	—
7	Bacon	210	—	—	—	—	—	—
8	Ham	185	—	—	—	—	—	—
9	Sausages	226	72	1	1	—	74	32·7
10	Potted meats	165	27	2	—	3	32	19·4
11	Preserved meats	135	—	—	1	—	1	0·7
12	Brawn	56	6	—	—	—	6	10·7
13	Fresh fish	43	—	—	—	—	—	—
14	Preserved fish	44	—	—	—	1	1	2·3
15	Meat jellies	25	3	—	1	—	4	16·0
16	Fruit jellies	28	9	—	4	—	13	46·4
17	Pork pies	48	—	—	—	—	—	—
18	Lard	52	—	—	—	—	—	—
19	Jam	150	10	—	—	—	10	6·7
20	Preserved fruits	48	4	—	—	2	6	12·5
21	Fruit pulp	10	—	—	—	—	—	—
22	Preserved vegetables	49	—	—	—	17	17	34·7
23	Lime and lemon juice	78	1	—	—	—	1	1·3
24	Cordials	24	12	—	2	—	14	58·3
25	Fruit syrups	23	12	—	1	—	13	56·5
26	Temperance drinks	769	56	—	1	—	57	7·4
27	Imported beers	100	—	—	—	—	—	—
28	Wines and beers	32	—	—	—	—	—	—
29	Vinegar	77	—	—	—	—	—	
30	Meat extracts	50	—	—	—	—	—	—
31	Sauces and ketchups	10	5	3	—	—	8	80·0
32	Soups	49	1	—	—	—	1	2·0
33	Sugars	149	24	—	—	—	24	16·1
34	Spices	22	—	2	—	2	4	18·2
35	Miscellaneous[3]	29	2	—	—	—	2	6·9
	Totals	4,251	398	221	11	25	648	15·2

The principal vegetable dyes are annatto, turmeric, camwood, and logwood. To these may be added gamboge, saffron, and

[1] Six of these contained both vegetable and coal-tar yellows.

[2] One of these contained both vegetable and coal-tar yellows.

[3] Invalid foods, &c.

carrot juice, which are used by some dairy farmers, and burnt sugar or caramel, which is occasionally employed for darkening brandy.

Annatto is still the principal substance used by dairy farmers, though it is to some extent being replaced by aniline dyes such as methyl-orange. It is sold to the trade under various names, such as 'cowslip colour,' 'butter colour,' and 'oleo-butter colour'; occasionally it is mixed with a coal-tar yellow, such as tropæolin. It is used also for margarine to counterfeit butter. Annatto is an extract from the pulp of *Bixa Orellana.* This is usually sold either as an aqueous extract, or dissolved in cotton-seed oil. Of the commercial preparations the quantity recommended varies from a tea-spoonful in 16 to 1 in 60 gallons of milk, a proportion of about 1 in 20,000 to 1 in 80,000 respectively. According to Mr. Droop Richmond, the chemist of the Aylesbury Dairy Company, the usual quantity is about 1 part in 30,000, which is equivalent to 1 part in 1,500,000 of actual colouring matter (bixin).[1] For butter about one teaspoonful is added to 3 or 4 gallons of cream, and for cheese an ounce to about 30 lbs. The necessity for the addition of pigments to dairy products, if such exists, occurs chiefly during the winter, when the natural colour is usually paler than in the summer. According to the evidence of Mr. James Long, a member of the Central Chamber of Agriculture, a rich colour can be maintained throughout the year by the addition of a Jersey or Guernsey cow to every ten or twelve cows, and by a due selection of animals of the shorthorn breed.[2] Mr. T. Carrington Smith, Chairman of the Dairy Products Committee of the Central Chamber of Agriculture, was also of opinion that the colour of even winter butter could be maintained by natural means.[3]

As regards the physiological action of annatto, nothing appears to be known. Probably it is perfectly harmless, at all events in the quantities in which it is employed.

[1] Report of Departmental Committee. [2] *Ibid.* [3] *Ibid.*

Turmeric is occasionally introduced into piccalilli, and some samples of mustard have been found to consist of a mixture of mustard and starch with the addition of this colouring matter. There is no reason to suppose that in the quantities employed any injury to health will result.

Of the other vegetable dyes, logwood is well known in medicine as an astringent in virtue of the tannic acid it contains; the dose of the decoction (1 part in 20) is from 1 to 2 fluid ounces. Gamboge, on the other hand, is a powerful purgative, the pharmacopœial dose being from ½ to 2 grains. Both of these are therefore objectionable as colouring matters. The latter is now rarely if ever met with, its use having been supplanted by the relatively cheaper and less harmful aniline dyes. The former is said to be found in cheap wines, but there appears to be no foundation for the statement, as we can find no record of logwood having been detected of recent years.

The mineral dyes or stains at present used are all metallic compounds. Reference has already been made to a number of poisonous metallic salts, which were formerly largely used in colouring confectionery, but as they are now rarely if ever employed they call for no further comment. The two chief metals in present use are copper in the form of the sulphate for green vegetables and fruit, and oxide of iron for sausages, cocoa, confectionery, anchovies, bloater paste, sauces and condiments, and other foods of a dark red tint. One of the commonest forms in which an iron compound is used is known as 'Armenian bole,' which is an oxide mixed with a silicious earth. Although but little exception can be taken on purely medical grounds to the employment of such a compound, its addition is not infrequently made use of to disguise adulteration. Thus, Dr. Dupré, in analyzing a sample of cocoa, found it to contain only 30 per cent. of cocoa, the remainder being chiefly starch and sugar coloured with iron.[1]

Copper Salts.—Copper, being by no means an inert substance, may be expected to exert some deleterious effect on

[1] Report of Departmental Committee.

the consumer, and many prosecutions under the Sale of Food and Drugs Acts have been taken, with varying success, in different parts of the country, on account of the use of copper salts in colouring vegetables. The only evidence which has so far been adduced is of a theoretical nature, and unless special feeding experiments are instituted the effects of copper are likely to remain in doubt, since, even if a dish of vegetables coloured by this means is suspected of having caused dyspepsia or other symptoms after a mixed meal, it is obviously difficult, if not impossible, to fix the responsibility on this particular constituent.

Copper sulphate, which crystallizes with 5 molecules of water, is employed both externally and internally in medicine. It is a powerful astringent, the pharmaceutical dose being ¼ to 2 grains. In larger doses of from 5 to 10 grains it acts as an emetic, and if this effect fails, inflammation of the gastric mucous membrane is liable to occur. Lauder Brunton says: 'Small doses absorbed into the blood appear to have a tonic action on some parts of the nervous system, and exert an astringent action on mucous membranes.' It is 'excreted by the mucous membrane of the intestine, by the bile sweat, and kidneys.' So far as is known it is not cumulative – i.e. it does not tend, like lead, to accumulate in the system. In a weak solution it inhibits the digestive ferments when the observations are made *in vitro*. The proportions of copper sulphate capable of arresting the action of the enzymes is as follows: ptyalin, 1 part in 7,500; pepsin, 1 part in 110; pancreatin, 1 part in 6,600.[1] Even in minute quantities copper salts are fatal to certain fresh-water algæ, and even to pathogenic bacteria such as the Bacillus typhosus. Many of the public water supplies in the United States are subject to the growth of algæ and protozoa, such as anabœna and uroglena, rendering the water unfit for consumption at certain seasons. Dr. George Moore, of the scientific staff of the United States Government, made experiments with a number of germicides, and found that

[1] Report of Departmental Committee, p. 393. Appendix XVI.

sulphate of copper in dilutions of 1 in 10,000,000 to 1 in 50,000,000 was sufficient to kill the algæ. He further tried the effect of the salt on a large scale in the case of the reservoir of a town in Kentucky which was quite overgrown with anabœna. The reservoir had a capacity of 25,000,000 gallons, and it was found that a proportion of copper sulphate equivalent to 1 part in 4,000,000 destroyed the growth in twenty-four hours. In a similar instance, the water of a reservoir was purified in five days by 1 part of copper sulphate in 8,500,000. Experimenting with typhoid and cholera bacilli, Dr. Moore found that these were killed in four or five hours by 1 part of copper sulphate in 100,000, and that on a large scale this proportion was sufficient to sterilize a water supply. Copper sulphate added to water in this manner seems to disappear on standing; apparently it is precipitated as a hydrate or carbonate, or as an organic compound which settles on sedimentation. The salt appears to have more effect on plant than on animal life, since goldfish and minnows are unaffected by a strength of 1 in 200,000.[1] Rideal and Baines have repeated Dr. Moore's experiments with different results. Copper sulphate was found to destroy the typhoid bacillus in three hours at a strength of 1 in 10,000, and bacillus coli at a strength of 1 in 1,000. One part of copper chloride in 10,000 destroyed both bacilli in three hours, but weaker solutions were ineffective.[2] Even when simply allowed to stand for twenty-four hours in a clean copper vessel, water infected with the typhoid bacillus is apparently freed from this organism. Fleet-Surgeon P. W. Bassett-Smith[3] has confirmed the germicidal action of copper salts, and bright metallic copper on a number of micro-organisms, and has found in addition that iron and zinc exert a similar effect.

Sulphate of copper has been used in America in over fifty cases for the destruction of algæ in water reservoirs, and the

[1] *Journal of State Medicine*, vol. xiii. pp. 108, 364.
[2] A paper read at the Congress of the Sanitary Institute, Glasgow, 1904.
[3] *Journal of State Medicine*, vol. xiii. p. 388.

consumption of the water afterwards has not been found to produce any ill effects. The quantity of copper used is exceedingly small, and little, if any, remains in the water after the deposition of the algæ. In any case, the quantity cannot be compared with the amount contained in peas and other vegetables greened with copper, yet as water is used in large quantities and every day, the question as to whether traces of copper contained therein are likely to endanger health is an important one. Moore and Kellerman, Government Physiologists, in their report to the W. S. Department of Agriculture[1] state as the result of their inquiries that, 'There is no authentic record of fatal copper poisoning, and many of the best authorities do not consider copper a true poison: they hold that it is a natural constituent of the body, and in minute quantities has no effect upon man.' Copper is undoubtedly very widely distributed in nature, and traces are found in many plants and animals. Dupré and others have found it in the liver and kidneys of man and domesticated animals, the amount sometimes exceeding 1 part in 20,000. It occurs in wheat, barley, linseed, peas, mustard, cocoa etc. It appears to be an invariable constituent of oysters. The amount present in these substances varies, and somewhat different results are obtained, in estimating such minute quantities as occur in these natural products, according to the process adopted. The following Table is from an article by Paul and Townley[2] on the 'Detection of Copper in Vegetable Substance.'

Paul and Townley's estimation:

	Parts of metallic copper in 10,000 of the substance		
	Maximum		Minimum
Oysters	3·03		1·81
Cocoa, pure		·47	
Cocoa containing sugar and starch	·58		·29
Brandy	·01		·05
Whisky		·04	
Preserved Peas	·54		1·40

[1] *Bureau of Plant Industry.* Bulletin No. 76.
[2] *Pharm. Jour.* June 6, 1896.

Vedrödi's estimation:

	Parts of metallic copper in 10,000 of the substance	
	Maximum	Minimum
Winter Wheat	8.6	2·5
Summer Wheat	3·0	2·5
Barley	0·9	0·1
Linseed	1·9	1·4
Peas	1·5	0·9
Mustard Seed	1·0	0·9

Vedrödi's method of estimation probably gives higher results than is obtained by more modern processes, otherwise many vegetable substances contain more copper than do others to which a salt of copper has been added for improving or preserving the colour. The largest amount found in the samples of preserved peas by Paul and Townley does not equal the maximum recorded by Vedrödi, whose results were obtained with unpreserved peas.

When a soluble salt of copper is added to green vegetables such as peas, a portion enters into combination with the chlorophyll forming a body which has been called copper phyllocyanate, and any excess combines with the proteid matter forming what has been termed copper leguminate. The former compound has in solution a characteristic spectrum; it is easily soluble in alcohol and chloroform but not in water. It is this compound which gives the characteristic green colour to preserved vegetables. The leguminate not having nearly the same depth of tint, its copper compound is useless for 'greening' purposes; hence if more copper salt is added than is necessary to combine with the chlorophyll, the vegetable contains an unnecessary amount and is to this extent objectionable. After extracting the chlorophyll compound with alcohol the compound with legumin can be dissolved in water rendered slightly alkaline by the addition of caustic soda [1]; hence by estimating the copper in the two solutions an approximate

[1] *Das Kupfer*. Dr. A. Tschirch, p. 33

idea can be obtained of the relative proportion of the two copper compounds, and if any appreciable proportion is found in the alkaline solution it is probable that more copper has been used than was necessary for the preserving process.

Lehmann,[1] who has devoted much attention to the action of copper salts, says: 'Of demonstrable severe acute poisoning cases by copper produced by its admixture with food, not a single one has come to my knowledge. The reports in literature refer either to poisonings by ptomaines or to quite different poisons. . . . The danger of chronic poisoning by preserved vegetables . . . has, according to what has been said, probably never existed.' He quotes experiments made by Bourneville, Touissant and others showing that the system rapidly becomes habituated to salts of copper. For example, Kant 'took for fifty-one days copper acetate, beginning with 5 mlgr. and then increasing to 10, 15, 20, 25, and for the last sixteen days 30 mlgr. The last dose is almost equivalent to 0·1 gram copper sulphate. He experienced no trace of indisposition.' Tschirch,[2] whose monograph on 'Copper,' published at Stuttgart in 1893, treats of the presence of the metal in animal and vegetable foods in an exhaustive manner, considers it proved that the small quantity of copper found naturally in foods or introduced carefully into the same for colour preserving is perfectly harmless, the metal being excreted by the liver and kidneys so rapidly that no accumulation occurs. He admits that larger quantities produce ill effects. His experiments with men and animals lead him to the conclusion that the largest amount which could be taken daily without danger was 0·1 gram of copper for a man weighing 60 kilogrammes. The degree of solubility of the copper salt taken is, he asserts, without influence, the quantity and not the solubility of the copper compound being alone of importance. Where the above quantity is exceeded, symptoms of poisoning may appear, but

[1] *Methods of Practical Hygiene.* Translated by Sir W. Crookes, vol. ii. pp. 377–8.

[2] *Das Kupfer*, p. 114.

very quickly disappear, the system returning to its normal condition. In round figures Tschirch gives 0·05 gram copper oxide per kilogram of preserved vegetables as being absolutely harmless even if a kilo (2¼ lb.) be consumed daily. Lehmann,[1] in a more recent study, has found copper in a greater number of unsophisticated articles of diet than has been hitherto supposed, and computes that under ordinary circumstances each individual takes with his daily food 0·02 gram of copper. He thinks that harm may ensue if by the use of preserved vegetables the amount consumed daily reaches 0·120 gram. Tschirch's opinion corroborates this. He thinks that so long as the total quantity of copper ingested does not exceed 0·1 gram per kilogramme of the food there can be no question of any injury to health by any preserved vegetable of which not more than ½ a kilo is consumed by a person per day. 'To prohibit absolutely copper in food or drink,' he adds, 'is equivalent to prohibiting plants to absorb it from the soil, and to include bread, oysters and many other such articles of food in the category of articles "injurious to health."'[1]

The quantity of sulphate of copper which has been found in preserved vegetables varies considerably. The usual amount appears to be from 2 to 3 grains per pound (expressed as the crystallized salt), but as little as a ¼ grain and as much as 26½ grains per pound have been recorded.[2] There is no doubt that bottled peas soon lose their green colour if preserved without copper, becoming brownish, although retaining their flavour. The copper also appears to harden the testa or outer covering of the pea, rendering it less liable to disintegrate. Peas preserved without copper render the liquid in which they are kept turbid when shaken, and this has led to such peas being seized and condemned as unwholesome, although the prosecution failed when the case was tried. No substitute has yet been found for colouring vegetables, and, according to some experiments made by Professor Tunnicliffe, 2 grains per pound is

[1] *Arch. Hygiene*, xxiv. quoted in *Year Book of Pharmacy*, 1897, p. 204.
[2] Report of Departmental Committee.

approximately the smallest quantity of copper sulphate which is efficient in maintaining a dark-green colour, peas containing half this amount being of a yellowish tinge at the end of six months. The actual amount of the salt which must be added to the peas in the process of preservation is considerably in excess of that which is permanently retained by them. Thus, in one of his experiments, 8 grammes of copper sulphate were used by Dr. Tunnicliffe for 15·9 kilos of peas, which were found after the process to contain 74 mlgm. of copper (about 296 mlgm. of copper sulphate) per kilo after ten minutes' boiling, but the quantity taken up by the peas appears to be proportional to the strength of the sulphate in solution, when the time of boiling remains constant.[1]

When peas are boiled with copper sulphate there is apparently a definite combination between the metal and certain constituents of the pea, legumin and chlorophyll, and the whole of the pea is impregnated. The metal is not removed by plain water, acids, or alkalis, and the colour is not due to the natural tint of the copper salt. There is some conflicting evidence as to the extent to which the copper is capable of being removed by the digestive ferments. Mr. W. Collingwood Williams found that about 40 per cent. of the whole copper was dissolved out after peas had been subjected to the action of either pepsin and hydrochloric acid, or of pancreatic extract, for three hours in an incubator. Dr. J. Spottiswoode Cameron, on the other hand, was able to recover practically the whole of the copper from a sample of peas by the action both of pepsin and hydrochloric acid, and of an alkaline pancreatic solution, the digestion being allowed to proceed at body temperature for twenty-four hours.[2] In the present state of knowledge concerning the action of small doses of copper on the human subject, the desirability of the addition of this substance to vegetables must be largely a matter of personal opinion. On the one hand it is certain that copper is a poisonous substance even in moderate quantities, and it is highly probable that some, if not

[1] *Ibid.*, Appendix V. [2] Report of Departmental Committee.

all of it, in preserved vegetables is in a form which is soluble in the digestive juices. On the other hand it is certain that, if the copper is omitted, the vegetables will lose their colour, and it is generally held that the appetizing appearance of food has considerable influence on the digestive processes. Three out of four of the members of the Departmental Committee agreed in condemning the use of salts of copper, whilst Professor Tunnicliffe considered that the public would be sufficiently protected if the colouring matter were declared, and if the quantity were limited to half a grain of metallic copper per pound (·07 parts per 1,000).

Copper is prohibited in Germany, Austria, and Hungary, whilst in certain parts of Switzerland and Italy 1 part in 10,000 of metallic copper is permitted. In the United States it is not forbidden, provided that the addition is notified and the amount stated. In France there was formerly an order prohibiting the use of copper, but this has subsequently been rescinded after a number of scientific inquiries on the subject.[1]

Tin Salts.—Chloride of tin has been extensively used to colour and give a bloom to beet-sugar, causing it to resemble Demerara sugar, but it is probable that this custom has now ceased.[2] Save that it enhances the value of the sugar by improving its appearance, and thus permits of a fraudulent substitution, the addition is harmless.

Coal-tar Dyes.—The last, and probably the largest, class of dyes is that which comprises the coal-tar colours. They are practically unlimited in variety, and are used for confectionery, jellies, jams, meat—especially sausages—dairy products, temperance beverages, and wines. Apart from their function of producing a pleasing appearance, they are undoubtedly used fraudulently, as in margarine to make it resemble butter, in beet-sugar crystals to resemble Demerara sugar, and in adulterated mustard to counterfeit pure mustard; whilst over hams and tongues a compound that may consist of borax, salt,

[1] Report of Departmental Committee, Appendix I. [2] *Ibid.*, Appendix XVII.

creosote, and a red coal-tar dye, is sometimes brushed to make the meat appear well smoked.[1]

The quantity of dye used is generally very small, rarely exceeding 1 part in 1,000, and being often less than 1 part in 100,000. The pigments are usually of the 'azo' class, and generally sulphonated when required in a soluble form. In dairy products, for instance, the two commonest coal-tar dyes are dimethyl-amido-azo-benzene (butter-yellow) and certain tropæolins, which are sulphonated azo compounds.

The trade names are sometimes misleading; for instance, a dye used in confectionery and called 'vermilion' is a pure aniline colour. Many of the stains used in pathological, bacteriological, and chemical laboratories, such as eosin, Bismarck brown, picric acid, fuchsin, methylene blue, Hoffmann's violet, methyl orange, and Congo red are also employed for colouring articles of food and drink.

Owing to the very small quantities of these dyes which are necessary to produce the desired effect it is almost impossible to form an opinion as to whether or not they are likely to be prejudicial to health. Many of the coal-tar products which are used in medicine are liable to produce toxic effects, and, on account of idiosyncrasy, even in ordinary doses. Sulphate of anilin has been used medicinally in ½ to 3 grain doses, but has produced cyanosis. A case is recorded of a woman who drank 3 ounces of marking ink, chiefly consisting of aniline dye, with fatal results; two 4-grain doses of acetanilide (phenylacetamide) have been known to cause very serious symptoms; a 10-grain dose of phenazone (antipyrin, phenyl-dimethyl-iso-pyrazolene) has caused toxic symptoms and a rash; many cases of poisoning by sulphonal (a dimethyl-methane-diethylsulphone) have been recorded; 15 drops of nitrobenzole may prove fatal. All these substances appear to have similar toxic effects, the chief clinical symptoms being cyanosis and faintness, while the blood gives the spectrum of methæmoglobin, and the urine may contain hæmatoporphyrin.

[1] Dr. Hope, Report of Departmental Committee.

Mr. Cochrane, of the Pennsylvania Station, found that 24 to 32 drops of aniline yellow and methyl orange produced headache, loss of appetite, nausea, vomiting, and nervous depression.[1]

Weyl found that the following aniline dyes were poisonous: picric acid, dinitrokresol, Martius' yellow, Bismarck brown, Orange II., and mustard yellow; and there is a case on record in French literature of a person who took 3½ grammes of dinitrokresol, with fatal results.[2]

Apart from such instances of what may be termed gross poisoning, nothing is known as to the effects of small doses of the coal-tar products on the human system.

In Austria-Hungary a decree of 1866 forbids in food the use of any colouring matter which contains metals (iron excepted), gamboge, picric acid, or aniline. But in 1895 a large number of aniline dye-stuffs which do not contain arsenic were permitted to be used for sweetmeats, liquors, &c., specimens of such colours to be submitted yearly to official examination. Ultramarine was only permitted when free from arsenic, and in such small quantities that in a 10 per cent. solution of water its presence is not distinguishable.

All harmless vegetable colouring matters are allowed, and saffron, chlorophyll, and cochineal are largely employed.

In France, a decree of December 29, 1890, sets out a list of colours which are prohibited, and also a list of certain coal-tar derivatives which are permissible in sweetmeats, lozenges, ices, and liquors. No colouring matter is allowed in wines or margarine.

In Germany the following pigments are prohibited for colouring foods: those containing antimony, arsenic, barytes, lead, cadmium, chromium, copper, mercury, uranium, zinc, tin, gamboge, coralline, and picric acid.

In Italy the colouring of margarine is prohibited, and certain scheduled noxious colours are forbidden.

[1] Mr. James Long, Report of Departmental Committee.

[2] Professor A. Wynter Blyth, Report of Departmental Committee.

In the United States no colouring matter is to be used, unless each package bears testimony as to the name and amount.[1]

The only instance of illness due to the action of colouring matter, which has come under our observation, was that of a child who had eaten a considerable quantity of red cachous. The urine became of an intense red colour, and the boy feeling sick, the mother promptly sent for a medical man. In this case, no doubt, the child had consumed an excessive quantity of the sweets in question, and it is not improbable that the sugar and flavouring matter rather than the colouring material upset his digestive system, the colouring matter in the urine merely causing alarm. The production of these highly flavoured and coloured sweetmeats at a very low cost is not an unmixed blessing, and it is conceivable that they may be productive of harm, especially if used by children and in excessive quantities.

In the present state of knowledge the case for and against colouring matters can hardly be better summed up than in the words of the Departmental Committee:

'126. In regard to the colouring matters of modern origin, while we are of opinion that articles of food are very much preferable in their natural colours, we are unable to deduce from the evidence received that any injurious results have been traced to their consumption. Undoubtedly some of the substances used to colour confectionery and sweetmeats are highly poisonous in themselves, but they are used in infinitesimal proportions, and before any individual has taken enough of colouring matter to injure him, his digestion would probably have been seriously disturbed by the substance which they were employed to adorn.

'127. The employment of copper sulphate to colour peas and other vegetables has been carefully considered by us. It is highly undesirable that what is admittedly a poisonous substance should be used, even to the smallest extent, in

[1] Report of the Departmental Committee, Appendix I.

connection with such food as may be consumed in considerable quantity. The public have got into their heads that vegetables ought to be green, and green they insist upon having them. Direct proof that vegetables containing copper are injurious to the consumer is from the very nature of the case difficult to obtain, and we must admit that we have not succeeded in obtaining it. There is evidence pointing to the conclusion that the copper, when added to the vegetables, forms a compound which is not easily soluble in the human economy. There is, however, evidence of a contrary character, and it is not clear to us that the copper added becomes, or remains, insoluble under all conditions. Be this as it may, recent events[1] have so incontestably demonstrated the serious and widespread mischief which may result from the consumption of food and drink, other than sweetmeats, containing even minimal quantities of poisonous metallic substances, that we are strongly of opinion that such poisonous substances should be rigorously excluded.

'128. There is such a wide choice of colouring matters suitable for the dairy trade, that no inconvenience would arise from restricting it to the use of innocuous substances, as these may be defined and permitted in the manner hereafter suggested. But the same reason which we have given for the prohibition of preservatives in milk offered for sale, namely, the large quantity thereof which may be consumed by an individual, appears to render it highly undesirable that any colouring matter should be permitted in milk. There is this further consideration, that milk is sold as an absolutely raw, unmanufactured article, of which the purchaser is entitled to be aware of the natural colour, and to draw his own conclusions therefrom as to quality.

'129. In the butter trade and still more in the cheese trade artificial colouring has long been established. Highly coloured goods find favour in some markets, uncoloured or faintly coloured goods in others. We have not found that in the

[1] I.e. the epidemic caused by arsenic in beer.

interest of the consumer any interference is necessary with the customs of the trade in this respect.

'130. In regard to margarine, we have to deal with a cheaper and relatively inferior article, invariably coloured to resemble a more costly and superior article, and probably the only means of protecting the public from imposition would be to prohibit the introduction of any colouring matter into margarine which shall cause it to resemble butter. Be the regulations as to the sale of margarine under declaration what they may, they cannot protect the customer who calls for bread and butter at an hotel or restaurant from being served with bread and margarine, and paying for it at the rate charged for the superior article. But as the margarine may be assumed to be a perfectly wholesome article of diet, it does not fall within the terms of our reference to make any recommendation upon a practice which is not attended with risk to the public health.'

It will be noticed that the Committee referred to the opportunities which the use of colouring matters afford for substituting inferior for genuine articles in the case of margarine, and, as we have indicated, other instances have been brought to the knowledge of public officials: for example, cocoa, mustard, and smoked hams.

The recommendations referring to colouring matters made by the Departmental Committee were as follows:

'B. That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Acts.'

'F. That the use of copper salts in the so-called greening of preserved foods be prohibited.

'G. That means be provided, either by the establishment of a separate Court of Reference, or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in foods, and to prepare schedules of such as may be considered inimical to the public health.'

Of the four members of the Committee responsible for the report, Professor Tunnicliffe alone took exception to paragraph 127 and recommendation F, referring to the use of copper in preserved vegetables, and in a short minority report he said that he could conceive of no conditions under which the small quantity of copper present in properly preserved peas could be injurious to any consumer to whom the peas themselves would be harmless. As, however, unnecessarily large amounts of copper are often present in vegetables permanently coloured by it, he recommended that the presence of copper should in every case be declared, and that its amount should be restricted to half a grain of metallic copper per pound.

CHAPTER XVI

MINERAL POISONS WHICH MAY OCCUR IN FOOD AND DRINK

Arsenic.—Arsenical compounds are very widely diffused in nature, and it has long been known that infinitesimal traces can be discovered in many materials used as food, or in the preparation of articles of food, but it was not until the great outbreak of arsenical poisoning, which occurred among beer drinkers in 1900, that serious attention was given to the subject. In November of that year Dr. E. S. Reynolds, of Manchester, came to the conclusion that the cases of peripheral neuritis under treatment at the Infirmary were due to arsenical poisoning; as all the patients were beer drinkers he suspected the beer, and upon examining samples he discovered the presence of dangerous proportions of arsenic in many. A Royal Commission was appointed in February 1901 to ascertain what amount of recent exceptional sickness and death was attributable to arsenic, and whether such exceptional sickness had been due to arsenic in beer or to other food substances. This Commission, after collecting a large mass of evidence, published its final report in 1903, and to this report we are indebted for much of the information contained in this section. The Commission found that many thousands of persons had been affected, principally in Lancashire and Staffordshire, but Manchester and the neighbourhood suffered most severely, it being estimated that in Manchester and Salford alone at least 3,000 persons suffered from arsenical poisoning, and that all the persons affected were addicted to the use of beer. The epidemic was traced to the consumption of beer from certain breweries using glucose made by a single firm. Samples of

this glucose yielded arsenic varying from 0·015 to 0·131 per cent., equivalent to 1·05 and 9·17 grains of arsenious oxide per pound. This arsenic was further traced to the sulphuric acid used in the manufacture of the sugar, some samples containing as much as 2·5 per cent. of arsenious acid. The amount of poison present in beers brewed with this sugar differed widely. 'Not only did the proportion of these sugars used in different beers vary greatly, but there is further material difference due to the stage at which the sugar was introduced into the beer.' The evidence goes to show that, in the process of brewing, a portion of the arsenic contained in arsenical brewing sugar added before fermentation will be removed by the action of yeast, and possibly also in other ways; whereas, if arsenical sugars are used as 'priming' after the beer has left the fermenting vessels, the whole of the arsenic present in the 'priming' solution will apparently remain in the beer. The quantity found in the implicated beers varied from $\frac{1}{4}$ grain or even less to $1\frac{1}{2}$ grain per gallon, but in one sample no less than 3 grains per gallon were detected.

The examination of beers from other makers not using the implicated sugars revealed the fact that arsenic was frequently present in quantities varying from $\frac{1}{100}$ to $\frac{1}{10}$ of a grain of arsenious acid per gallon. In these cases the poison has been traced through the malt to the fuel used in kiln-drying, and in a few instances traces of arsenic were discovered in various chemicals used in brewing. The compounds of arsenic present in the fuel are oxidized during the combustion, and a proportion of volatile arsenious acid is formed which condenses on the malt and in the kilns and flues. As hops are also kiln-dried, many samples were examined, and in nearly every case found to be free from arsenic, but in rare instances traces were detected.

The examination of many other articles of food and drink rarely reveals the presence of arsenic, or of traces sufficiently large to determine, but, as both sulphuric acid and hydrochloric acid frequently contain arsenic in appreciable quantities, and

are extensively used in the preparation of food and drinks, there is a danger of the poison being introduced into such preparations.

Glucose is made by the action of sulphuric acid or hydrochloric acid upon starch, and in samples other than that implicated in the outbreak of 1900–1 arsenic has been occasionally found. In the Government Laboratory 500 samples were examined. In the majority no arsenic was detected; in the remainder, with only two exceptions, the amount present was below $\frac{1}{250}$ grain per pound. Invert sugar, used by brewers of beer and cider, and in the manufacture of non-alcoholic beverages, is made by the action of acids on cane or beet sugar, and may, therefore, contain arsenic. That made by means of the impure acid which led to the epidemic contained from 1·4 to 4·3 grains per pound, but other samples rarely contained as much as $\frac{1}{250}$ grain per pound. Glycerine is another sweet substance which is liable to contain large traces of arsenic, 3 or 4 grains per pound having been reported. Caramel produced from glucose has been found to contain $\frac{1}{4}$ grain of arsenic per pound. Phosphoric acid and phosphates, boric acid and borates, tartaric acid and citric acid, acetic acid, sulphurous acid and sulphites, yeast and yeast foods, and alkaline carbonates, are all liable to contain traces of arsenic. Armenian bole, a red oxide of iron used in colouring sausages, &c., has been found to contain as much as 0·8 grain of arsenious acid per pound. Most of the malt now prepared contains less than $\frac{1}{250}$ of a grain per pound, but samples have been examined containing $\frac{1}{20}$ or $\frac{1}{6}$ of a grain of arsenic per pound. The foods, &c., which require to be systematically examined for arsenic are 'beer, foods in which a considerable proportion of glucose is used (e.g. table syrups, jams, marmalade, and certain forms of confectionery), or which, like glucose, are prepared by the use of a relatively large quantity of sulphuric or hydrochloric acid (e.g. treacle, golden syrup, vinegar made from converted raw grain), and foods the principal basis of which is malt or yeast, or into which glycerine

enters in any considerable proportion.'[1] A trace of arsenic has been found in West Indian sugars which have been treated with chloride of tin to give colour and 'bloom,' and was doubtless introduced with the chemical. Traces have also been found with the following substances: chocolate (adulterated with Armenian bole), liquorice, sweets, chicory (doubtless from process of drying), coal-tar colours, and gelatine.

Arsenic is often used as a seed dressing, and may be present in superphosphate manures, but there is no evidence showing that the grain or roots of crops so treated contain any arsenic. This poison is, it is alleged, sometimes given to poultry to aid in the fattening process, but fowls, fed on food containing distinct traces of arsenic, when examined yielded arsenic only from the feathers. Cooking vessels are alleged to be sometimes enamelled with a preparation containing arsenic, but the Departmental Committee found no arsenic in the enamel of twenty-six specimens which they caused to be examined.

The Committee obtained no evidence of arsenical poisoning due to the use of any article of food or drink other than beer. The excessive prevalence of alcoholic neuritis in Manchester and Liverpool leads to a suspicion that arsenical poisoning had been prevalent around these centres for some years before the epidemic outburst, and this view is supported by the fact that such cases of neuritis have become less common in those cities since 1902. In that year a series of cases of arsenic poisoning, three of which proved fatal, occurred in Halifax, all the persons attacked being beer drinkers. In this instance the implicated beers had been brewed from malt impregnated with arsenic, and the samples examined appeared to contain about $\frac{1}{30}$ of a grain of arsenious acid per gallon. This quantity, therefore, seems capable of causing symptoms of poisoning, and Professor Delépine, from experiments made on rats, concludes that the continuous daily ingestion of $\frac{1}{100}$ of a grain of arsenic along with beer or food may be prejudicial to the human subject. The Departmental Committee express

[1] Report of the Departmental Committee.

the opinion that any quantity of arsenic, however small, is not to be regarded as admissible in any articles of food, and they think 'it should be the aim of food manufacturers to exclude arsenic altogether from their products.'

In the epidemic of 1900 probably over 6,000 persons were affected, and a total of seventy fatal cases occurred after the nature of the disease was recognized, but it is probable that many others were erroneously attributed to 'chronic alcoholism,' 'cirrhosis of liver,' 'Addison's disease,' 'locomotor ataxy,' and various forms of neuritis. Dr. Niven, the Medical Officer of Health for Manchester, discovered a remarkable fall in the birth-rate in Manchester in 1901, a fall which was most marked in those districts which had principally suffered during the epidemic. This, he is inclined to attribute to the effect of the arsenic. The symptoms produced by the arsenical beers were of different clinical types, and are thus summarized in the second report of the Departmental Committee:

'There occurred throughout the epidemic (and particularly it would seem towards its termination, when people had been drinking arsenical beer for many weeks or months, and so had taken considerable quantities of the poison), an abundance of cases in which, once the possibility of arsenic was entertained, there was comparatively little difficulty in deciding, on clinical grounds, that the illness was consistent with arsenical poisoning. Such cases presented symptoms corresponding to those described as characteristic of subacute poisoning by arsenic, or which are met with in the poisoning which occasionally results from long-continued doses of arsenic taken medicinally. They showed, for example, inflammation of various mucous surfaces, leading to coryza, huskiness, lachrymation, and the like, gastro-intestinal disturbance and diarrhœa, peripheral neuritis affecting sensory and motor nerves, and in some cases associated with herpes, or with well-marked erythromelalgia, keratosis, or recent pigmentation corresponding with that which not infrequently occurs in persons taking arsenic for long periods.

'On the other hand, symptoms of the above kind were often

slight or absent altogether, and one of the most instructive points in connection with the outbreak is the occurrence of cases in which the symptoms, if taken by themselves and apart from the epidemic, would not have appeared to be readily or sufficiently explained by the suggestion that arsenic was the cause of the illness. Thus, in several comparatively mild cases, the sufferers complained merely of burning hands and feet, or they showed a variety of skin eruptions, which are observed in many conditions which have nothing to do with arsenical poisoning. In other cases, again, the main symptoms were those resulting from dilated heart, and special difficulty arose in cases showing evidence of well-marked peripheral neuritis not associated with symptoms pointing clearly to arsenic, and which appeared practically identical with "alcoholic neuritis," a disease previously considered to be the result, alike in drinkers of beer and spirits, of the toxic action of alcohol on nerve tissue.'

It is probable that this neuritis is manifested more frequently when arsenic is taken along with alcohol than without, a view which is confirmed by an epidemic of arsenical poisoning which took place in Hyères in 1887. Numerous cases of paralysis occurred, and it was an alcoholic drink—wine contaminated with arsenic—which caused the outbreak. This observation has led to the suggestion that the arsenic forms some compound with the organic matter found in wines and beers, differing in its effects from those of pure arsenious acid. There is no chemical evidence, however, of the existence of such a compound. The cacodyl compounds present some analogy to the hypothetical body, but they are relatively less toxic than arsenious oxide, and neither cacodylates nor allied bodies could be obtained from the implicated beers.

Great differences in individual suceptibility were observed in the epidemic mentioned. This is only what would have been expected, as tolerance of arsenic is well known to exist amongst Styrian peasants, Cornish miners, makers of arsenical compounds, &c., whilst the administration of extremely small

medicinal doses has been known to produce serious effects. Many people who drank large quantities of the arsenical beer remained apparently unaffected, whilst others who had taken comparatively small quantities exhibited symptoms of poisoning.

Arsenic appears to be eliminated with comparative rapidity, but under certain conditions a cumulative action must be acknowledged in order to account for the observed facts. Many patients, for example, admitted to hospital in 1900 continued to show increasing signs of poisoning for weeks after beer had been discontinued, and an examination of the urine in several instances indicated that arsenic was being eliminated three weeks or more after the patient had been admitted to hospital, while in an exceptional instance Dr. Dixon Mann found arsenic in the urine after fifty-nine days.

The arsenic appeared to be eliminated, not only by the urine, but in the sweat, by the shed epidermal scales, and by the hair. Dr. Dixon Mann showed that tissues containing keratin have a special affinity for arsenic, and he thinks that this may explain the effect of arsenic upon nerve tissue, since the nerve sheaths consist largely of keratin.

Arsenical poisoning has also occurred from the use of confectionery coloured with arsenical pigments, and from the use of wearing apparel next to the skin dyed with colours containing arsenic or mordanted with an arseniate. Wall-papers containing arsenic have also given rise to symptoms of poisoning, and fatal results are believed to have followed on rare occasions. Whether the evil effects are due to dust from the paper, or to the impregnation of the air of the room with some intensely poisonous organic compound of arsenic, is not definitely known, but the latter explanation is the more probable, since such volatile arsenical compounds undoubtedly exist. Decomposing animal juices containing arsenic are intensely poisonous, and boiled potato made into a paste with a solution of arsenious acid, if kept in the dark, gives off some volatile matter with a distinct alliaceous odour. It is probably

a compound of this kind, derived from the arsenic-stained paper, which causes the symptoms of arsenical poisoning. These products seem to be the result of the vital processes of low forms of vegetable life, since the *Aspergillus glaucus* and *Mucor mucedo* grow on arsenical pastes, with evolution of a garlic-like odour. The *Penicillium breviculare* flourishes so freely on paste, containing infinitesimal traces of arsenic, producing the characteristic odour, that it has actually been suggested as a delicate test for the presence of arsenic. These moulds grow most readily in the presence of oxygen, and at a temperature between 60° and 95° F.

Since the dangers attending the use of arsenical stains, paints, and dyes have been recognized their use has practically been abandoned, but occasionally cases of illness occur which are traceable to the use of such compounds.

Antimony.—Quite recently Mr. Pond, of Liverpool, has directed the attention of the medical profession[1] to the fact that antimony is a constituent of the rubber rings forming a portion of the patent stoppers so largely used for mineral water, ale, and other bottled drinks, and that these rings are liable to crumble or wear, particles of the rubber getting into the liquid, to the possible detriment of the health of the consumers. His attention was first directed to this matter by a patient who was suffering from depression, with cold clammy hands, and had immediately afterwards to be operated upon for acute appendicitis. She was accustomed to drink daily about half a dozen bottles of non-intoxicating drinks sealed with these stoppers. Upon examining liquids bottled in this way he found in several cases particles of the red rubber which had evidently been derived from the ring on the stopper, and many of the stoppers were considerably worn. In one instance the ring had lost about 9 grains in weight, of which one-third would be antimony sulphide. Mr. Pond thinks these rubber particles, containing as they do about 30 per cent. of antimony sulphide, when introduced into the stomach, by

[1] *The Lancet*, June 10, 190?, p. 1,610.

cumulative action produce antimonial poisoning, which may be a cause of appendicitis, probably also of dilated stomach, gastric ulcer, chronic constipation, &c. The ingestion of antimony may, in his opinion, lead to: (*a*) 'weakening of the muscular coat of the cæcum and vermiform appendix, and the resulting appendicitis; (*b*) weakening of the muscular coat of the stomach and dilatation of the stomach; (*c*) irritation of the mucous membrane of the stomach and intestines, and thereby some cases of gastric and intestinal ulcers; and (*d*) weakening of the muscular coat of the intestine, and some cases of chronic constipation.'

These rubber rings are said to contain approximately:

Rubber	54 per cent.
Antimony sulphide . . .	32 ,,
Red oxide of zinc . . .	13 ,,
Free sulphur	0·35 ,,
Lime.	0·65 ,,

It is obvious, therefore, that the particles of rubber getting into any beverage introduce an appreciable amount of antimony, and it is possible that the continued use of such beverages may cause ill health. According to Allbutt,[1] 'Towards antimony people exhibit a peculiar idiosyncrasy. Some are easily affected by the minutest dose, others are extremely tolerant of it.' Exceedingly small doses frequently administered cause a metallic taste in the mouth, with frequent vomiting, great prostration, clammy sweats and feeble pulse. In some cases vomiting may be absent. Lehmann[2] states that 1 to 10 mlgm. of tartar emetic taken daily may cause chronic illness. Antimony like arsenic tends to accumulate in the nervous tissues, but no records appear to exist of its having produced any symptoms of peripheral neuritis such as is caused by arsenic. It is excreted with the urine, and it is probable that in any case of suspected poisoning antimony would be found in this fluid if the metal were the cause of the symptoms.

[1] *System of Medicine*, vol. ii. p. 942.

[2] Lehmann, *Practical Hygiene*, vol. xi. p. 382.

The subject is one of considerable interest and importance, and doubtless attention will be given to it, until Mr. Pond's theories are proved or disproved.

A series of experiments made by one of us shows that no antimony enters into solution in soda water, lemonade, ginger beer, ale, stout, and wines from the rubber used with the stoppers, but that fine particles of such rubber are frequently found in the liquids, especially if the rings are old and becoming brittle. Thus, in six bottles of liquids with comparatively new rings, traces of the rubber were only found in one, whereas in five bottles with old rings particles of rubber were found in three. The amount was very small, but doubtless on occasions it may be appreciable. When a number of the rings were boiled in soda water for half an hour the antimony actually dissolved was too small to estimate, but in the residue left on the filter the antimony present averaged 1 mlgm. per ring used. Boiled with a dilute solution of tartaric acid similar results were obtained, but the antimony was a little under 1 mlgm. per ring. All the rings had a red colour, and contained roughly from 15 to 25 per cent. of antimony. In opening some bottled fruits it was found that occasionally comparatively large pieces of the rubber rings broke off, but such pieces would be removed before the fruit was poured from the bottle. Our present knowledge will not permit of our asserting that there is any danger of poisoning from this cause, but it is obviously desirable that poisonous substances, especially if known to have a cumulative action, should not be allowed to come in contact with articles used for food or drink.

Lead.—Although cases of lead poisoning are far from uncommon, the metal is rarely introduced into the system with the food or with beverages, other than water. Epidemics of lead poisoning have occurred from the use of moorland waters stored in leaden cisterns or passing through lead pipes, and it is from the study of these outbreaks that we have learnt that infinitesimal amounts of lead administered over a lengthened

period are capable of producing serious effects, and even death. Water containing $\frac{1}{100}$ of a grain of lead per gallon is stated to have caused symptoms of poisoning, but this is doubtful, since waters acting on lead will at one time contain even less than $\frac{1}{100}$ of a grain per gallon, and at others possibly as much as 1 grain, the amount depending upon the length of time the water has been in contact with the metal of the pipe or cistern, the temperature and other factors. There is a general consensus of opinion that a water containing an average of $\frac{1}{10}$ of a grain per gallon is dangerous. Assuming that a person imbibes 3 pints of such water daily he would take into the system a little over 1 grain of the metal per month. Very small quantities of lead, therefore, in a substance likely to be consumed in any quantity, or for considerable periods, should be sufficient to condemn it as dangerous to health.[1]

Aerated waters not infrequently contain traces of lead derived from the 'tin' lining of the copper cylinders in which the water is impregnated with gas, the tin used for tinning copper vessels almost invariably containing a certain percentage of lead. Tin-lined lead pipes also are not free from danger, as in some way a small quantity of lead becomes diffused throughout the tin, and the lining is apt to give way at the bends. Lead has also been found in cider and ale, in the latter case derived from the pipes leading from the casks to the pumps at the counter. Naturally the ale which has been standing in the pipes all night will contain an appreciable amount of lead, especially if the ale has an acid

[1] In one large northern town, supplied with upland water, cases of undoubted lead poisoning occur occasionally which are attributed, rightly or wrongly, to the water supply. The plumbo-solvent action of the water is very slight, so much so that it gives negative results when tested after the manner recommended by Houston. Repeated examinations show that the water which has been standing over night in the pipes contains between $\frac{1}{100}$ and $\frac{1}{200}$ grain of lead per gallon, whilst during the day the amount falls to $\frac{1}{500}$ or $\frac{1}{1000}$ grain per gallon. The patients are usually women, and although it is impossible to remove suspicion from the water, inquiries in connection with other articles of food giving negative results, it must be remembered that pills containing lead are occasionally surreptitiously employed by women to procure abortion, and these may be the cause of the symptoms observed.

reaction. Fruits and vegetables preserved in tinned iron cans take up traces of both lead and tin, the amount varying with the acidity of the fruit, and to a certain extent with the time the fruit, &c., has been in the tins. In such cases the lining of the can usually shows signs of the effect of the acid, varying from a mere discoloration to distinct evidences of corrosion. The amount of lead dissolved in this way is small compared with the amount of tin. Experiments made in the laboratories of the Massachusetts State Board of Health with various kinds of tinned fruits, broths, soups, salmon, and lobster, showed that the total amount of lead dissolved and contained in the whole tin (0·5 to 1 kilo) rarely exceeded 1 mlgm., whilst the quantity of tin was frequently 100 times as much. If the acid liquid can come in contact with the solder, or if pieces of solder are found in the tin, the amount of lead dissolved may possibly be increased. Many articles of food and drink are preserved in vessels closed with a capsule of soft metal containing lead, or in bottles in which a ring of soft metal is placed between the stopper and neck. In such cases traces of lead may be dissolved. Citric acid, tartaric acid, and cream of tartar not infrequently contain lead, taken up from the pans in which the chemicals have been prepared, and occasionally minute particles of lead have been found in these articles, apparently due to the scraping of the leaden pan in order to separate the crystals which had adhered to the side during evaporation. These chemicals are largely employed for making beverages, hence the presence of any appreciable quantity of lead should be sufficient to condemn them as being dangerous. There need be no hesitation in condemning such samples, as the chemicals can be prepared, at little if any additional expense, in such a manner as to prevent contamination with lead. Tea which has been in contact with the lead foil of the packing case has been found to contain traces of the metal.

Certain enamels used for glazing earthenware and for coating iron cooking vessels, and the tinning on copper vessels,

generally contain lead, and may give up traces of the metal to the food prepared therein.

Lead poisoning has also been produced by the efficacious but dangerous method of cleaning out decanters by means of shot.

It is obvious, therefore, that lead may be derived from very many sources, and though the quantity may be small, the metal may continue to accumulate in the system until capable of causing injury to health. There is certainly also a great difference between individuals in their susceptibility to the action of lead, a peculiar idiosyncrasy rendering some persons much more liable than others. There is also an hereditary disposition, and young women seem especially likely to be affected. There can be no doubt also that sufferers from kidney disease are very liable to injury, the limited powers of elimination being still further decreased.

According to Oliver[1] lead poisoning occurs in four forms. 'In the first colic is the most important symptom; in the second the central nervous system is profoundly affected, the patient being the subject of epileptiform seizures, called "lead encephalopathy"; the third is the neuro-muscular form in which "wrist-drop" is the most marked symptom; and in the fourth are included all those cases of chronic plumbism characterized by profound cachexia, early decrepitude and albuminuria.'

In the chronic form, resulting from the long-continued use of water and other beverages or articles of food containing small quantities of lead, a peculiar anæmic condition is usually first observed, and when the mouth is examined a blue line is noted round the margin of the gums where they are in contact with the teeth. This blue line is not absolutely pathognomonic, since other metals have been known to produce it, but in the latter instances it speedily disappears, whereas if due to lead it is very persistent. It is absent where teeth have been drawn, and frequently where the tooth-brush is

[1] Allbutt's *System of Medicine*, vol. ii. p. 969.

adequately employed. The anæmic condition results in a general condition of malnutrition, especially affecting women, causing menstrual troubles and a great tendency, when pregnant, to abort. Attacks of colic are frequent, 'wrist-drop' may be observed, or the joints may be gouty, or show signs of rheumatism. Sight may be affected from neuro-retinitis, and loss of vision may result. The functional activity of the liver and kidneys becomes deranged, and chronic interstitial nephritis may be found post-mortem. Death usually occurs from some intercurrent disease, the natural resistance of the constitution being so reduced as to make the sufferer an easy prey. When the action of lead is suspected the history of the case, together with the detection of traces of lead in the urine, may be regarded as conclusive evidence.

Tin.—Prior to the discovery of ptomaines, toxins, and other poisons produced in decomposing animal matter, the ill effects caused by foods preserved in tinned receptacles were usually attributed to the presence of tin, dissolved by the juices of the food. At the present time no one seriously contends that the amount of tin in solution in these foods has any effect upon the system. As a rule the quantity is very small, rarely amounting to one grain per pound of food substance. Very acid fruits may dissolve more than this quantity, and should be preserved in vessels of glass, but as it would be practically impossible to prove injury, or serious danger, to health from the use of such fruit, the subject is one to which no further reference need be made.

Copper.—The compounds of copper are rarely found in appreciable quantity in articles of food save such green vegetables as have had their colour preserved by the addition of a salt of copper, and this subject is referred to at length in the section relating to colouring matters.

PART IV

CHAPTER XVII

FOOD INSPECTION: LAWS RELATING THERETO

The statutory powers governing the seizure and condemnation of unsound food in the provinces are contained in sections 116, 117, 118, and 119 of the Public Health Act, 1875, extended by section 28 of the Public Health Acts Amendment Act, 1890, and for London in section 47 of the Public Health (London) Act, 1891.

By virtue of section 116 of the Public Health Act, 1875, a medical officer of health or inspector of nuisances is enabled to inspect and examine, at all reasonable times, any animal, carcass, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour or milk exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man. The onus of proving that the food was not exposed or deposited for any such purpose, or was not intended for the food of man, rests with the party charged. If the article of food appears to the medical officer or inspector to be diseased, or unsound, or unwholesome, or unfit for the food of man, he may seize and carry away the same himself or by an assistant, in order to have the same dealt with by a justice.

Under section 117 the justice, if it appears to him that the article of food seized is diseased, or unsound, or unwholesome, or unfit for the food of man, must condemn the same, and order it to be destroyed or so disposed of as to prevent it from being exposed or used for the food of man.

Further, the person to whom the same belongs, or did belong at the time of exposure for sale, or in whose possession or on whose premises the same was found, is liable to a penalty not exceeding twenty pounds for every animal, carcass, or fish, or piece of meat, flesh or fish, or any poultry or game, or for the parcel of fruit, vegetables, corn, bread, or flour, or for the milk so condemned, or, at the discretion of the justice, without the infliction of a fine, to imprisonment for a term of not more than three months.

There are therefore two steps necessary in dealing with unsound food. In the first place it must be seized personally either by the medical officer of health or inspector of nuisances, and submitted to a magistrate for condemnation; and, secondly, further proceedings may be taken, if the food seized is condemned, for the enforcement of the penalty. A second information is required for this purpose, the hearing usually being fixed for a date subsequent to that on which the food is condemned.

Section 117 further provides that the justice empowered to inflict the penalty need not necessarily be the magistrate who ordered the food to be disposed of or destroyed—an obvious convenience. It will be seen, however, that the food must not be destroyed without a magistrate's order, otherwise the local authority are liable to damages (Ormerod *v.* Mayor of Rochdale, 62 J.P. 153). In the proceedings for the condemnation of the food it is unnecessary to summon the owner to attend, but the magistrate may hear evidence as to the condition of the food, and if he declines to condemn it the owner can obtain full compensation, including the costs incurred in opposing the condemnation (*In re* Bater and Williamson and Mayor, &c., of Birkenhead, L.R. 1893, 2 Q.B. 77). Under section 116 live animals have been seized.

In districts where Part III. of the Public Health Acts Amendment Act, 1890, has been adopted, the list of articles of food which can be seized and dealt with is made, by virtue of section 28 subsection (1), to include all articles

intended for the food of man, and moreover if the food has been sold, provided it has been properly seized, the person in whose possession it was found, or to whom the food belonged at the time of exposure for sale, is liable to the penalties authorised by section 117 of the Public Health Act, 1875.

Under section 28 subsection (2) of the 1890 Act, a magistrate may condemn any such article of food and order it to be destroyed or disposed of, as mentioned in section 117 of the Public Health Act, 1875, if satisfied on complaint being made to him that such article is diseased, unsound, unwholesome, or unfit for the food of man, although the same has not been seized as mentioned in section 116 of the 1875 Act. Apparently under such circumstances no penalty follows beyond the destruction of the article, and, judging from Firth *v.* McPhail (J.P. 69, p. 205), proceedings other than seizure will fail unless there has been an exposure for sale by the defendant, and not merely a deposit for the purpose of sale. This difficulty does not exist in London.

Section 118 of the 1875 Act provides a penalty if any person prevents the medical officer of health or inspector of nuisances from entering any premises for the purpose of inspecting the articles of food specified in section 116, or if he obstructs or impedes the medical officer, or inspector, or his assistant, when carrying into execution the provisions of the Act.

Section 119 provides for the obtaining of a search warrant on complaint made on oath by a medical officer of health, or by an inspector of nuisances, or other officer of a local authority, before a magistrate, for entry of any building, or part of a building, in which such officer has reason for believing that there is kept or concealed any of the articles detailed in section 116. There is also a penalty against any person obstructing such officer in the performance of his duty under such warrant.

The extension of powers conferred by section 28 subsection (1) of the 1890 Act, also embraces the provisions of sections 118 and 119 of the 1875 Act.

The provisions as to the sale of unsound food in the Public Health (London) Act are on similar lines to those in the two provincial Acts, the penalties being, however, increased to fifty pounds, or six months' imprisonment with or without hard labour.

Under section 15 of the Markets and Fairs Clauses Act, which is incorporated with the Public Health Act, any person exposing for sale any unsound food in a market under the control of the sanitary authority is liable to a penalty, but the procedure differs materially from that under the Public Health Act, since the justice must order the food seized to be further examined by competent persons before making any order for its destruction or otherwise. This important safeguard to the seller is not included in the Public Health Act. Under the Fairs Clauses Act, bye-laws may be made for preventing the sale, exposure for sale, &c., of unwholesome provisions.

Under Section 31 of the Public Health Acts Amendment Act the occupier of any slaughter-house may have his license revoked if he is convicted of having in his possession or on his premises the carcass of any animal, or any piece of meat or flesh, which is unfit for human food.

It is evident, therefore, that a medical officer of health should be acquainted with the appearances commonly met with in food which will justify him in asking a magistrate to condemn a specimen as being 'diseased or unsound, or unwholesome, or unfit for the food of man,' and it is by no means always easy to steer a clear course between making seizures which cannot readily be justified, and allowing articles of food to be sold which theoretically might be expected to be capable of causing illness. Our knowledge of the effects of many abnormal conditions of food on the human economy is by no means an exact one, though it is becoming clearer with the advance of bacteriological and chemical research. To take a concrete example, it is usual to condemn as unfit for food the carcass of a cow which has died in parturition, though, as far as we are aware, there is no evidence that such meat is

prejudicial to health. Theoretically one would suppose that the tissues are filled with abnormal metabolic products derived from the muscular contractions in the course of labour which would render it unwholesome, and as a rule butchers acquiesce in the condemnation of such a carcass. Again, in the condition known as 'braxy' in sheep the general practice is to condemn the carcass, although it is apparently regarded as a delicacy by some Scotch shepherds.

The increasing consumption of bananas recently led to some conflicting evidence in a North of England police court. A quantity of this fruit was seized by the medical officer of health as being over-ripe and so unfit for the food of man, but the owner produced a number of witnesses connected with the trade, whose evidence was to the effect that bananas are not at their best until they begin to soften, and that in this condition they most nearly resemble the state in which they are eaten in their native land. The fruit was destroyed by the order of the court, though it is by no means certain that the opinion of the medical officer of health was the correct one. There is no doubt that acts of injustice have frequently been perpetrated by the destruction of an article of food before the owner has had the opportunity of having it examined by an expert, or without his having time to communicate with the merchants from whom it was purchased. It is very difficult sometimes to decide whether an article is unfit for food or not, and although from the sanitary point of view it may be the better course to seize it and get it condemned, it must not be forgotten that such action may most seriously affect the reputation and business of a perfectly innocent person.

The most essential qualification of a food inspector is an intimate knowledge of the characters of articles of food of all kinds, and of the various changes to which they are prone when kept under different conditions. Without this intimate knowledge it will be impossible for him to decide whether any condition is abnormal or not, or whether the condition is such as to justify the seizure of the article of food as being unsound

or not. Even with this knowledge it is impossible in many cases to arrive at a conclusion which may not be challenged. A piece of fresh beef admittedly wholesome becomes by keeping decidedly putrid and admittedly unwholesome. The change is a gradual one, and it is impossible for anyone to say at what moment the wholesome meat becomes so changed as to be unwholesome. Not only may opinions differ, but customs differ. A piece of meat kept until it is tainted would be condemned, yet the stage of decomposition attained may not be so advanced as that reached by game when 'high' and in perfect condition. Cheese is not condemned because it is affected by moulds or infected by mites, whilst most other articles of food so affected would be unhesitatingly condemned. Physical, chemical, and sometimes bacteriological tests need on occasions to be applied, but unless these can be done quickly, they are of no practical utility. For example, a batch of oysters or a can of milk cannot be seized and kept until the results of a bacteriological examination are known; if there is not anything obviously abnormal, there must be some other ground for seizure, but a subsequent bacteriological examination may be made to justify the seizure.

CHAPTER XVIII

UNSOUND FOOD. MEAT

In America, Germany, and other countries, far greater supervision is exercised over the food supply than in Great Britain. In the numerous public abattoirs animals are carefully examined before slaughter, and the carcasses and organs are inspected during the process of dressing. This control is doubtless of great importance, but the amount of disease produced in this country, at least, from the consumption of unwholesome food, and especially by butchers' meat, is either very small indeed, or it escapes observation, and this notwithstanding the fact that as a nation we are great flesh consumers. Outbreaks of food poisoning from time to time occur, but these have usually been attributed to cooked meats, the change which rendered them deleterious having occurred subsequent to the cooking, and not being antecedent thereto. The correctness of these views will be considered later. The chief dangers to be apprehended from the use of unsound meat are the dissemination of tape-worms, echinococcus disease, trichinosis, tuberculosis, and 'ptomaine poisoning,' and systematic meat inspection may not only prevent these infections in man, but also prevent the infection of animals which are allowed to eat infected offal. The latter point is too frequently overlooked, but is an important one to the farmer and cattle breeder. Of secondary but still of considerable importance is the detection of fraud, by the palming off upon the unsuspecting public of the meat of immature and diseased animals at the price of sound and wholesome meat. The consumer himself will, as a rule, take care to avoid eating 'putrid' meat.

Domestic animals probably suffer from as great a variety of diseases as human beings, and certain of these diseases are capable of being transmitted from animal to animal, or from animals to man. The veterinary surgeon examining an animal during life may be able to decide whether it is healthy, or, if not, whether it is suffering from any disease which would render the carcass or any part thereof unfit for food, but usually the meat inspector has to form an opinion from the examination of the dressed carcass, or portions thereof, without knowing anything of the animal previous to slaughter, and frequently without even the opportunity of examining the internal organs or all the portions constituting the carcass. This renders the process of meat inspection much more difficult, though sometimes the examination of even a portion of a carcass may enable the inspector to decide that the animal was suffering from some disease, and possibly even to specify the disease. Fortunately, the diseases most readily transmissible to man can be discovered by inspection, if the carcass or any portion thereof is so infected as to be dangerous to the health of the consumer, and in other cases, although the particular disease from which the animal suffered may not be known, an opinion can be formed as to whether the flesh is wholesome or not. In addition to the inspection of the fat and muscular tissue, the examination of the viscera and lymphatic glands is always a great aid in arriving at a correct conclusion, and should be adopted as a matter of routine wherever possible; but it is obviously impossible in the case of imported carcasses and of meat exposed for sale in shops.

In good meat the muscle should be firm and elastic. The colour will depend largely on the age of the animal. The cut section should be of uniform appearance—that is, the interior of the joint should not differ from the exterior, and the consistency should be uniform. The section should have a marbled appearance from the presence of interstitial fat, and there should be an absence of gelatinous or purulent fluid in the septa between the muscles. The intermuscular tissue should

not be soft or tear easily, and when a piece of red litmus-paper is applied to it, it should not be turned blue. The fluid which oozes from it should be thin, red, neutral, or slightly acid in reaction, and without offensive odour.

If the colour is a deep purple it suggests that the animal has not been properly slaughtered and bled, and, therefore, that it was killed on account of some accident or disease. If the colour is pale and the flesh 'watery,' the animal had probably been suffering from some disease causing dropsy. Commencing decomposition is indicated by the colour becoming paler, the flesh softer, and the juice alkaline, and by the distinctive smell of fresh meat being superseded by that of putrefaction. It is not until decomposition has advanced that the colour becomes greenish. Any evidence of decomposition should lead to the condemnation of the meat. Abnormal odours may be due to some physic administered to the animal before death, and such odours are rendered more evident if a little of the meat is chopped fine and drenched with hot water.

By thrusting a knife into the joint the consistency as well as the smell of the interior can be tested. The resistance to the passage of the knife should be uniform, and the knife blade when removed should not have any objectionable odour. The meat of a healthy animal should 'set' within twenty-four hours, and this property is often made use of as a criterion in doubtful cases. Rigor mortis is hastened by very strong muscular contractions before death, as in hunted animals, or in cases of tetanus, or of strychnine poisoning. In such a carcass rigor mortis may commence within a few minutes of death. It is frequently delayed in diseases such as septicæmia and dropsy.

The fat varies in colour in different species of animals, being white in young cattle, sheep, goats, and hogs, and yellow in old cattle. In calves it is often at first a reddish yellow-white. In any case it should be firm and free from hæmorrhages.

Animals which have been subjected to so-called 'emergency slaughter' should be looked upon with great suspicion, and the meat should only be passed after a very careful examination of

all the cavities and organs, as well as of the flesh itself. Apart from the question of the flesh being unwholesome on account of the cause which has led to the necessity for slaughter, the bleeding is in such animals not infrequently defective, and the keeping qualities are thereby impaired. If the history of the illness is not sufficient to enable a decision to be arrived at, special attention should be paid to the serous membranes, the thoracic and abdominal organs, and the lymphatic glands, for evidence of tubercle, and to the spleen for anthrax. In addition to the routine examination of the chief organs, the following should not be forgotten: abnormal conditions of the sexual passages connected with parturition, parenchymatous inflammation of the udder, gastro-enteritis, peritonitis, and pleurisy. As regards the flesh in such cases, 'If the meat of animals slaughtered on account of disease shows an alkaline reaction within twenty-four hours after death, the meat is to be considered, in doubtful cases, as unqualifiedly foul, and therefore unfit for food. Likewise, in doubtful cases, the unfitness for food of the meat of animals slaughtered on account of disease is unquestionable if, within forty-eight hours after death, the muscle fibres show under the microscope a loss of their characteristic cross-striation, a granular cloudiness, and a disintegration into fragments.'[1]

In any case of doubt a decision should be deferred for at least twenty-four hours in summer and forty-eight in winter. In septicæmic conditions there will probably be sufficient alteration in the appearance and odour of the meat after these periods to afford reliable criteria for further action. In the section dealing with epidemics of meat poisoning, stress is laid on the fact that in certain infections bacteria may be circulating in the system before death, but may escape detection in the flesh immediately after slaughter, and that rapid multiplication takes place after death, rendering the carcass a most dangerous article of food, although normal in appearance and smell.

[1] *Handbook of Meat Inspection*, Ostertag, translated by Wilcox, 1904, p. 736.

A detailed bacteriological examination of doubtful meat will probably require too many days to be of any practical value, though the fact that in healthy flesh, examined soon after slaughter, the interior is sterile has occasionally been of service.

When an animal is slaughtered on account of an accident the meat is usually passed as sound, if on examination no abnormal conditions are to be found. The same is also true when the slaughtering is effected on account of insuperable obstacles to parturition.

In instances of 'natural death' each case must be judged on its merits. It is generally infectious diseases and septicæmia which are responsible for sudden deaths, and, in addition to the danger to the health of the consumers on this account, the absence of proper bleeding, and the retention of the thoracic and abdominal viscera favour rapid decomposition. Such carcasses as a rule should be condemned.

The meat of immature animals is not apparently unwholesome, but it is not usually considered marketable. During the first eight to fourteen days after birth the muscles are poorly developed, flabby, and watery. They may be soft enough to give way before the finger. There are, moreover, what may be termed æsthetic reasons for rejecting such meat. In many countries local regulations exist as to the minimum age at which animals may be slaughtered for food, and as a rule eight days may be considered as the lowest reasonable limit. The meat of fœtuses is universally held to be unmarketable, although among certain gourmands, notably the ancient Romans, such food was considered a delicacy.

Of the non-infectious and parasitic disorders which lead to the condemnation of the whole or portions of the carcass, the commonest are œdema from heart, kidney, or liver disease, and tumours, the latter of which may be benign or malignant. In forming an opinion as to how much of the carcass should be condemned, each case would require to be considered on its merits.

The subjoined brief description of a few of the diseases of animals, which are of importance from the inspector's point of

view, may be useful in showing the degree of risk incurred by consuming the flesh of animals suffering therefrom, and the parts of animals most likely to be affected, and, therefore, requiring particular examination. Unfortunately there is nothing in this country analogous to the methods adopted in some parts of the Continent, where meat from diseased animals, if not absolutely condemned, may be stamped as inferior or diseased and so sold, the purchaser knowing exactly what he is buying and how to avoid any risk; or where certain meats are first treated by boiling or steaming so as to destroy all parasites and dangerous organisms, and the meat is then sold at a cheap rate to the poor. Here, we must either pass the meat as wholesome, or seize it and get it condemned as unsound, a method which no doubt on occasions results in the destruction of food which by appropriate treatment would have been quite wholesome and of full nutritive value.

Tubercular Diseases.—From the time of Koch's discovery of the tubercle bacillus until 1901, there was a general consensus of opinion that human and bovine tuberculosis were due to one and the same organism, although it was admitted that, whilst it was comparatively easy to infect cattle, pigs, sheep, horses, and other animals with tuberculosis by the use of bacilli of bovine origin, it was very difficult to infect cattle with bacilli of human origin. In 1901 Koch announced his opinion that human tuberculosis differs from bovine and could not be transmitted to cattle, basing it upon experiments conducted under his own observation, and alleging confirmation from the fact that a primary lesion of the intestine is rarely met with in man, as would be the case if the disease were communicable by the consumption of meat or milk infested with tubercle. This has such an important bearing upon public health that a Royal Commission was soon after appointed by the English Government to investigate the relations between tubercle in man and animals. Up to the present the Commissioners have only issued a brief interim report (1904),

in which they stated that they had inoculated bovine animals with more than twenty different strains of tubercle bacilli from human subjects, and that seven of these strains had proved capable of giving rise at once to acute tuberculosis in cattle. Most of the other strains produced more or less local lesions, but five of these, after being passed from one bovine to another, or through guinea-pigs, ultimately proved capable of producing general tuberculosis. The Commissioners, therefore, concluded that tubercle of human origin can give rise to bovine tuberculosis, the inference being that tuberculosis of cattle and man are practically identical in origin. Still more recently the Imperial (German) Board of Health has issued a report based upon researches carried out by Drs. Weber, Kossel, and Heuss, in which the opinion of Koch is confirmed. The reporters affirm that the bacillus tuberculosis humanus differs from the bacillus tuberculosis bovinus in its morphological, cultural, and pathogenic properties. Cattle inoculated with the bovine type at once contracted general tuberculosis, whilst those inoculated with the human type remained in good general health, and suffered temporarily only from the localized effect of the introduction of the bacilli. Animals fed on food infected with the bovine type were speedily affected, whilst those fed on similar food infected with the human type remained quite healthy. Similar results were obtained by inhalation experiments. It is probable, therefore, that two types really exist, and that the seven strains, which the British Commission found capable of producing bovine tuberculosis, were of the bovine type. The German Commission found this bovine type in six cases out of fifty-six of human tuberculosis, and all six cases were primary tuberculosis of the intestines and mesenteric glands occurring in children. The results obtained by Hamilton and Young, and published in the 'Transactions' of the Highland Agricultural Society of Scotland (1903),[1] appear to be diametrically opposed to those obtained by the German pathologists, since they had no

[1] Reprinted in *Public Health*, September 1903.

difficulty in infecting calves, by feeding, inoculation, and by spraying. Their conclusions are summarized as under:

1. That, although human tubercle is probably not as virulent for the calf as that derived from bovines, yet it can be readily inoculated upon that animal.

2. That this holds good whether the tubercle inoculated be derived from tubercular lymph glands, tubercular lungs, tubercular sputum, or tubercular urine.

3. That it produces this positive result irrespective of whether it be introduced by feeding the animal with the tubercular material, by subcutaneous inoculation upon a peripheral part, by respiration of a spray containing the bacillus, or by injection into the venous system.

4. That the organs most affected are those in immediate connection with the part operated upon.

5. That the lymphatic system is constantly involved in the resulting tuberculosis.

6. That when administered by the mouth tubercular sputum induces an abdominal lymph gland tuberculosis, without necessarily the intestine being in any way involved.

7. That when tuberculosis from a human source has been ingrafted upon a calf, it gains enormously in virulence by being reinoculated upon a second calf.

8. That the morphological characters of the bacillus may vary according to circumstances, and are no guide to the source of the organism under observation.

9. That the above facts go to favour the view that the human bacillus and that of bovines are identical, but modified somewhat by their environment.

10. That these results are a direct contradiction of those alleged to have been obtained by Koch and Schutz.

With such conflicting reports it is difficult to arrive at any definite conclusion, but it may be taken as proved that in a certain, but possibly small, proportion of cases tubercle bacilli of the bovine type are found in persons suffering from tuberculosis, and that the persons from whom such bacilli are

obtained had suffered from tuberculosis of the intestine and mesenteric glands, and that they had almost certainly been infected by tuberculous milk or meat. There is, therefore, some danger of infection from the consumption of the flesh of an animal suffering from tuberculosis, though possibly the danger is very small, much less indeed than has hitherto been supposed.

Since the infectivity of tuberculous meat is still probable, in dealing with tuberculosis the recommendations made by the Royal Commission of 1898 should be strictly carried out—the entire carcass and all the organs should be condemned :

(*a.*) When there is miliary tuberculosis of both lungs.

(*b.*) When tuberculous lesions are present in the pleura and peritoneum.

(*c.*) When tuberculous lesions exist in the muscular system, or in the lymphatic glands embedded in or between the muscles.

(*d.*) When tuberculous lesions exist in any part of an emaciated carcass.

The carcass if otherwise healthy should not be condemned, but every part of it containing tuberculous lesions should be seized :

(*a.*) When the lesions are confined to the lungs and the thoracic lymph glands.

(*b.*) When the lesions are confined to the liver.

(*c.*) When the lesions are confined to any combination of the foregoing, but are collectively small in extent.

As regards pigs the Commissioners recommended that the presence of tubercular deposit in any degree should lead to the condemnation of the whole carcass and all the organs. They further recommended that seizures shall ensue in any case in which the pleura of foreign dead meat shall have been stripped.

Although the post-mortem recognition of tuberculous deposits in animals usually presents no difficulties to those who are acquainted with similar processes in man, there are

certain differences in appearance between human and bovine tuberculosis which should be borne in mind. Speaking generally, it is unusual to find any large cavities in the lungs of animals suffering from tubercle, the commonest condition being a wide-spread tuberculous broncho-pneumonia, the amount of caseation which has occurred depending on the length of time that the disease has existed. The serous tuberculosis of cattle (grapes or perlsucht) has no counterpart in man. The tubercles on the pleura and peritoneum may be of any size, from miliary deposits up to large tumours 8 inches or more in thickness. In the kidneys of cattle the deposits may also be of a large size without breaking down, and may resemble new growths in consequence. The chief other pathological conditions with which tuberculosis is likely to be confounded, are actinomycotic deposits, caseous echinococci and cysticerci, caseated pentastomes, and strongylus nodules in the lungs of sheep. A microscopical examination may be necessary in doubtful cases, the presence of the characteristic mycelia indicating actinomycosis, the striated or lamellated condition of the wall denoting echinococci, whilst in the case of pentastomes and strongylidæ the claws or hooklets and the worms respectively will be found. The corresponding glands will, in addition, probably not be tuberculous.

The presence of coccidia in the liver of the rabbit gives rise to an appearance somewhat resembling tuberculosis. A microscopical examination will readily differentiate the two conditions (see Coccidia).

If tubercle is suspected, and if the thoracic and abdominal serous membranes and viscera are not available for examination, special attention should be paid to the lymphatic glands. The most important group from this point of view is the set of glands which lie in the interchondral spaces on each side of the sternum. They are situated about an inch in front of the costochondral articulations, and beneath the fascia next the pleura; generally they are partially covered by a layer of muscular tissue.

Another group affected early in tuberculosis is the set of glands situated on each side of the dorsal and lumbar vertebræ; they are embedded in fat, and may be removed by the butcher along with the viscera. Similarly the deep inguinal glands, embedded in fat and situated on the anterior lip of the pelvis, should be examined.

The popliteal glands are generally only affected in severe generalized cases of tuberculosis. The pharyngeal group is very seldom left in a carcass that has been dressed, but is usually attacked at an early stage of the disease.

Anthrax.—This disease affects man as well as animals, but it is very doubtful whether the disease is ever conveyed to man through the medium of meat. Butchers frequently become infected when cutting up an animal suffering from the disease, whilst those who eat the flesh remain entirely unaffected. In consequence of the frequency of such infection the Board of Agriculture and Fisheries has recently issued the following circular:

NOTICE TO BUTCHERS, SLAUGHTERERS, KNACKERS, and other persons engaged in Great Britain in slaughtering Animals, or in dressing or otherwise handling Carcasses of Animals.

ANTHRAX.

Cases come under the notice of the Board of Agriculture and Fisheries from time to time of persons having contracted Anthrax whilst engaged in slaughtering Animals, or in dressing or otherwise handling the Carcasses of Animals. In connection with inquiries made under the Diseases of Animals Acts, 1894 to 1903, into outbreaks of Anthrax, it appears from the reports of the Board's Inspectors as regards the outbreaks which occurred in Great Britain during the period from the beginning of July to the end of December of last year, that as many as twelve persons are known to have contracted the disease whilst so employed, and that six of these persons died, whilst in one case amputation of the arm became necessary.

The Board therefore think it desirable to warn persons against shedding the blood of an animal which appears to be ill from some unknown cause, and also against cutting or handling the carcass or skin of any animal which has died suddenly, until careful inquiries

have been made with a view to see whether or not any symptoms[1] of Anthrax had been exhibited during life. Should there appear to be any reason to suspect the presence of Anthrax, it is very desirable that the slaughter of the animal or the dressing of the carcass should not be commenced until steps have been taken to investigate the cause of illness or death, and that the owner should be warned of the grave risk to human life which might without such investigation be incurred.

If the course above indicated be followed in suspicious or doubtful instances, material assistance would thus be rendered to the respective Authorities concerned in dealing with this very dangerous disease in man and in animals.

T. H. ELLIOT,
Secretary.

Board of Agriculture and Fisheries,
4 Whitehall Place, London, S.W.
October 10, 1905.

Sheep are most susceptible to anthrax, but cattle are frequently infected, and occasionally pigs. Animals suffering from anthrax, or suspected to be so suffering, should be dealt with under the Anthrax Order of the Local Government Board. They are to be killed and buried unopened at a depth of not less than 6 feet, the carcass being covered with lime. It is obvious that, if the requirements of the law be complied with, the body of an animal suffering from anthrax would never be exposed for sale. There can be no hesitation, therefore, in condemning the carcass of an infected animal. The detection of the disease may be difficult if the spleen cannot be examined, as this organ is most markedly affected, becoming

[1] The symptoms of Anthrax may be summarized as follows:—The disease shows itself suddenly. It is very fatal, usually within forty-eight hours. It does not often in the United Kingdom spread with rapidity from animal to animal, but it may affect a number of swine at the same time if they have been fed on anthrax flesh or organs. A beast which a short time before appeared to be well is found dead or in a dying condition. Frequently blood oozes from the nostrils and the anus. In cattle there are no typical symptoms, but in horses and pigs the region of the throat is often found to be swollen.

After death the carcass is swollen. Blood is found around the nostrils and anus. The muscles are often infiltrated with blood at certain points. The lungs and glands are congested. The spleen is very much enlarged; it is softer and darker than normal, and its substance usually resembles tar.

greatly enlarged, and more or less diffluent, and the contents are of a tarry colour and consistency. Extensive hæmorrhages occur in all the organs, and especially under the epicardium. In pigs the spleen may be but little affected, the disease in this animal being chiefly characterized by œdema of the neck. The bacillus of anthrax is recognized with comparative ease and may be obtained from the spleen, or, if this is not available, from the hæmorrhagic infiltrations or the blood. Ostertag directs attention to the necessity for distinguishing between this bacillus and that of certain cadaver bacilli. The latter form spores in the carcass which the former never do, and are decolourized by Gram's method, whilst the anthrax bacilli retain the stain. An instance of human anthrax, apparently due to infected meat, is recorded in 'The Lancet,' 1905, i. p. 875.

Black-leg or Quarter-ill is an anthracoid disease affecting cattle, in which hæmorrhagic effusion takes place into the subcutaneous tissues of the hind or fore quarters. Extravasations are found in the internal organs, and in the blood the characteristic bacillus can be demonstrated. Malignant œdema is an analogous condition due to a specific organism. Both of them are probably communicable to man, and render the flesh of the animal unsound.

Braxy.—This is a disease of sheep which is endemic in certain localities. In Scotland it occasions annually the loss of some 100,000 or more sheep. It is probably of bacillary origin and has been confounded with anthrax. Infected sheep often die very suddenly. The animal begins to stagger, falls down, becomes comatose, and dies. The stomachs are found greatly inflamed, with ecchymoses especially in the fourth stomach. The flesh rapidly suffers decomposition, with the production of a very offensive odour. It is said to be eaten by Scotch shepherds. It is very doubtful whether the carcass of an infected animal is ever dressed for market. The term 'braxy' probably embraces more than one disease causing sudden death among sheep.

Swine-fever.—This is an exceedingly infectious disease, the occurrence of which has to be notified, and the local authority may cause not only the infected animal, but also all contacts to be slaughtered, and pay the owner compensation. It is due to a bacillus, and runs a course not unlike typhoid fever in man. If the animal is killed in the early stage and the internal organs removed, there may only be a redness of the skin and subcutaneous fat to indicate that the animal has suffered from any disease. If the alimentary canal can be examined, the large intestines will be found ulcerated, and diphtheritic deposits may be found in various parts of the alimentary canal from the mouth to the anus. In severe cases or in a later stage of the disease the flesh wastes, and may be pale or dropsical, and have a disagreeable odour. In Germany the flesh may be sold in a cooked condition. If the carcass shows any signs of being affected by the disease it should be condemned. There is no evidence, however, of the flesh of an infected animal being injurious to man, but the bacillus is apparently related to the colon group (B. coli, B. enteritidis, B. typhosus, and the paratyphoid bacillus), and also to the B. psittacosis, all of which are pathogenic to man.

Swine Erysipelas is said by Loeffler to be due to a bacillus, and is usually a rapidly fatal disease. There is no pronounced rigor mortis, and the flesh rapidly decomposes, hence carcasses rarely, if ever, reach the market. There is no evidence, however, of the unwholesomeness of the flesh; on the contrary, it appears to be eaten with entire impunity. The skin is of a dark-red hue, as is also the subcutaneous fat. Hæmorrhages under the serous membranes are common, the spleen is enlarged, the kidneys, liver, and heart show signs of degeneration, and the bacilli may be demonstrated in the blood or spleen pulp. The skin eruption affecting swine and known as 'diamonds' is not improbably related to this disease. The flesh of an animal suffering from swine erysipelas must be considered as unfit for food, unless it were slaughtered at the very onset.

Diphtheria, so called, in calves is apparently caused by a streptothrix, and is of an entirely different nature from human diphtheria. If the disease is local and the flesh normal in appearance the meat need not be condemned.

Septicæmia, Pyæmia, and Sapræmia may arise in connection with wounds, injury to the freshly torn navel cord, parturition, osteomyelitis, and sometimes apparently idiopathically. It is unnecessary to describe in detail the pathological distinctions of the three conditions, which are strictly comparable to those occurring in man. Apart from the symptoms during life, the commonest post-mortem appearances are petechiæ under the serous and mucous membranes and in the lymphatic glands, cloudy swelling of the liver, heart, and kidneys, and enlargement of many of the lymphatic glands. In pyæmia, metastatic abscesses may be present. Possibly a bacteriological examination of the flesh would prove of service in doubtful cases. As a general rule the flesh of such animals is to be condemned, though possibly in slight cases of sapræmia, where the meat, when kept under observation as indicated previously, appears to be normal, the flesh may not necessarily be prejudicial to health.

Rinderpest.—This terribly infectious disease occurs in epidemics. Cattle suspected of infection are immediately slaughtered, and buried or otherwise destroyed. Should an infected carcass reach the market, it is consoling to know that its consumption would do no harm. Troops have been fed on animals suffering from the disease in nearly all stages, and without ill effects.

Pleuro-pneumonia is another very infectious disease of cattle which necessitates the slaughter of the animal. So far as is known the disease is not communicable to man, and if the flesh is not deteriorated, being in all respects normal, it is quite unobjectionable and may be passed as wholesome, the lungs only being destroyed. It is difficult to recognize the disease in its early stage, when the animal merely refuses food and is feverish. Later, when the symptoms of pneumonia and

pleurisy are well marked, the diagnosis is easy. The lungs and pleura exhibit the usual post-mortem appearances. The characteristic features are the 'extensive affection of the interlobular connective tissue, and the presence of inflammatory foci of different ages in the pulmonary parenchyma between the diseased interlobular connective tissue strands.'[1]

Tetanus being a localized infection, the carcass of an animal which has been killed while suffering from the disease is not likely to infect man. Bleeding is, however, generally defective, and the meat of poor keeping quality.

Cow-pox and Vaccinated Animals.—Cow-pox is a trivial affection, never leading to the slaughter of the animal, and not affecting the value of the flesh for food. The sale of the flesh of calves which have been used for the production of lymph has given rise to much discussion, sentimental objections being raised against the use of such flesh as food. If in a healthy condition when slaughtered, the flesh is perfectly wholesome. In Germany 'the meat of vaccine calves and bulls in most abattoirs is admitted to the market after the removal of the œdematous infiltrated subcutis under the point of inoculation. No harm from eating such meat has ever been observed.'[2]

The flesh of cows and sheep suffering from pox may possibly be inferior if there has been much constitutional disturbance, but there are no grounds for condemning the carcass except in the rare cases of 'cadaveric' or 'gangrenous' sheep-pox.

Rabies is extremely rare, and considerable risk of infection would be run in dressing such carcasses. The flesh of an animal known to have been rabid should be condemned.

Glanders is almost confined to horses, cats, dogs, and goats, but is, of course, transmissible to man. Sheep appear to be slightly susceptible. The carcass of any food animal suffering from this disease should be destroyed without skinning.

Foot-and-Mouth Disease.—Cattle (and occasionally pigs) suffer from this disease, which generally appears in epidemics. It is characterized by the appearance of vesicles around the

[1] Ostertag, *Meat Inspection*. [2] *Ibid.*

margin of the tongue, the gums, mucous membrane of the cheeks and the nasal septum, and also on the border and cleft of the hoofs. The disease often runs a fatal course, and it is transmissible to man by direct contact. There is no evidence, however, leading us to suspect that the disease may be communicated by the eating of the flesh of an infected animal. It suffices, therefore, to destroy the obviously affected parts, but to pass the remainder of the carcass provided the disease has not caused any deterioration of the flesh.

Actinomycosis (Plate I.).—One other disease due to infection with an organism belonging to the vegetable kingdom, viz. actinomycosis, remains for special reference. Although this disease can be, by inoculation, transmitted from man to animals and from animal to animal, no case of direct transmission by food has been recorded, and there is no proof that the consumption of the flesh of an infected animal has communicated the disease to man. The ray-fungus is by some considered to be a mould, but is probably a streptothrix. It has no sheath, and forms long and short rods, simple and branched threads, spiral threads and coccus-like bodies. In the animal tissues it is characterized by the rosette-like arrangement of the threads, and their club-like swellings. It is probably introduced into the system, both in man and animals, by the sharp awns of barley and other cereals which pierce the mucous membrane of the alimentary or respiratory tract.

It affects cattle and pigs chiefly, but occasionally sheep and other animals are attacked. The tongue is the most frequent seat of this disease ('wooden tongue,' 'cancer'), the lower jaw coming next in order of frequency, then the upper jaw; when the skin and subcutaneous tissue are affected, large tumours ('wens') may be formed. The lips, pharynx, larynx, and other parts of the head are not uncommonly attacked, but the stomach, lungs, liver, and other organs may also be affected, and occasionally the disease becomes generalized. According to Ostertag actinomycosis does not produce suppuration in domesticated animals, but 'simply an extensive infiltration of round cells,

and, in the neighbouring tissue, giant cells of a more irregular shape than in tuberculosis.' Where suppuration occurs in such animals he attributes it to a mixed infection with pyogenic organisms. The growth becomes surrounded by a thick layer of connective tissue, but ulceration may occur. The lymphatic glands become affected, but do not suppurate or caseate. The disease may be confounded with non-malignant tumours and with tuberculosis, but the microscopic examination, revealing the presence of the fungus, enables a correct diagnosis to be made. In man the 'clubs' are absent, the growth consisting of threads and the coccus form. Pus formation is the rule, and the abscesses are apt to burrow in various directions. The lungs and abdominal viscera may be invaded, and in such cases the diagnosis may be obscure until the pus can be examined microscopically.

In cases of actinomycosis the general feeling in England is in favour of condemning the whole carcass, but such an extreme measure is perhaps hardly justifiable in early and strictly localized cases, if the affected portions are carefully removed. In the rare instances in which the disease is generalized the whole carcass should certainly be destroyed. On the Continent it is customary to remove only the affected portion, and to pass the remainder of the carcass. It should be borne in mind, however, that secondary deposits are not always easy to determine by the naked eye.

Poultry and Game.—The length of time which should elapse between slaughter and consumption in the case of poultry and game varies very largely with the different species, fowls and rabbits especially being liable to cause gastro-intestinal disturbance if decomposition has set in, whilst in the case of pheasants and other game no evil results usually follow in the early stages. There are only two important infective diseases to which poultry are liable: fowl cholera, and fowl diphtheria. The former occurs in chickens, geese, ducks, pigeons, turkeys, and pheasants; it is usually fatal in a few days, or even hours. Hæmorrhagic inflammation of the small intestine is found,

and occasionally hæmorrhage under the pericardium, and inflammation in the lung tissue. When the intestines have been removed, the cause of death may sometimes be ascertained by the presence of dark-blue patches at the lower part of the abdomen and on the internal surface of the thighs. If a pigeon is inoculated in the breast muscles with the blood of the suspected bird, it will probably die within forty-eight hours. If the disease is at all advanced it renders the flesh unfit for food, but it is apparently not transmissible to man. Fowl diphtheria attacks chickens and pigeons, with the formation of an inflammatory membrane in the mouth, pharynx, respiratory passages, or alimentary tract, and occasionally on the surface of the eyes. Hæmorrhages under the pericardium may be present, and the flesh should be considered unfit for food. The disease is, however, quite distinct from human diphtheria.

CHAPTER XIX

UNSOUND FOOD (*continued*). ANIMAL PARASITES

The number of animal parasites infecting animals used for human food is very considerable, but fortunately few of these are capable of also infecting man. The others are of no importance, provided care is taken not to confound them with parasites capable of directly infecting man, or of indirectly affecting him after a change of host. In the following pages a description is given of all the parasites capable of infecting human beings directly or indirectly, so far as our present knowledge extends, and where a harmless parasite is likely to be confounded with a dangerous one, the points requiring attention to effect a differential diagnosis are recorded.

Trichinosis.—This disease is believed to have been introduced into Europe by the grey rat, which came from Asia about 1770, and which is peculiarly liable to infection by the Trichina spiralis, as many as 100 per cent. in certain localities being found to be attacked. Others believe that the worm was introduced earlier in the eighteenth century by pigs imported from China. It was not, however, until 1860 that it became known that the disease was communicable to man, though in 1835 Sir James Paget had recognized the worm in the cadaver of an Italian; but it is probable that many cases of trichinosis had previously occurred, the patients being considered to be suffering from rheumatism, rheumatic fever, or typhoid fever. The cases recorded in this country are very few, but in France, Denmark, and Poland localized epidemics have occurred, and in Germany extensive outbreaks have frequently been recorded, hundreds of persons being attacked, with a

mortality rate of from less than 1 to over 30 per cent. This disease is invariably produced by the eating of infected pork, of sausages, or of similar prepared foods containing pork.

The cause of trichinosis is a nematode worm, the adult male of which is from 1·2 to 1·5 mm. long, and the adult female about 3·5 mm. They are ovo-viviparous, and develop in the stomach or intestine when the envelope of the embryo has been dissolved by the gastric juice. In the intestine further development takes place, the sexual organs appearing. After copulation the male disappears, being digested or ejected, and the young trichinæ are born about the seventh day after infection. These next make their appearance in the voluntary muscles (Plates I. and II.) and certain other tissues, but how they get there is a disputed question. Some affirm that they penetrate the walls of the intestines and travel along the connective tissue and spaces, but this seems very improbable, as the embryos at first possess no boring apparatus, and are said never to be found in the intestinal contents. Graham found that the adult trichinæ make their way into the interior of the Lieberkuhn's gland, and that the embryos discharged there find their way into the chyle vessels, and are thence carried into the blood, and by the blood to the muscles. The evidence which he adduces appears to prove conclusively that the old migration theory is quite incorrect. The female parent, having produced her thousands of embryos, ultimately dies and is apparently voided. About the end of the third week after the reception of the worms into the stomach the invasion of the muscles is complete. The embryos lie within the sheath of sarcolemma, and cause a certain amount of irritation leading to an increase of connective tissue, and the formation of a capsulated cyst. The embryo assumes the larval stage, coils itself up, and becomes quiescent. Fat cells may develop around the cyst, and at a later stage the cyst itself may become calcified. The encysted trichinæ survive a temperature much below freezing point, and after an infected ham has been

pickled or smoked they retain their vitality for many months, and may infect any susceptible animal into which they are introduced. The temperature necessary for their destruction is unknown. It has been stated by some observers that a temperature of 50° C. maintained for a few minutes is sufficient to kill them, whilst others affirm that they resist a temperature of 80° C. Many outbreaks have followed the use of boiled infected pork, hence it is evident that very thorough cooking is necessary to destroy those in the centre of a joint. It is very probable that it is to the more careful and thorough cooking of pork practised in this country that our practical immunity from this disease is due.

The symptoms of trichinosis in man vary at different stages of the infection. Within a few hours of the ingestion of the infected material there is more or less intestinal irritation, often resulting in vomiting and diarrhœa. About the end of the third week, fever ensues with severe muscular pain, œdema of the eyelids, &c. At a later date, as the larvæ become encapsuled, the symptoms subside. When death occurs, it is usually from the intense infection of the diaphragm and intercostal muscles. The disease may be confounded with typhoid fever, rheumatism, cholera, and beri-beri.

The principal muscles infected, and which ought therefore to be examined for this parasite, are the diaphragm, the muscles of the larynx and tongue, and to a less extent the abdominal and intercostal muscles. The cysts lie with their long axes parallel to the direction of the fibres. The only method of identifying trichinæ with certainty is by a microscopical examination, a magnification of 40 diameters being ample. The addition of dilute acetic acid to the muscle renders the cyst and worm coiled up therein clearer, or the sections may be immersed for a few minutes in liquor potassæ to make the muscle fibres translucent. The pig is the only animal used for food in which trichinæ have been found, and any carcass infected is unfit for food and should be unhesitatingly condemned.

Tapeworms.—These animals belong to the natural order Cestoda, and inhabit the intestinal canal of vertebrate animals. Twelve species are known which infest man, but most of them so rarely that only four need consideration. They are the Tænia mediocanellata, Tænia solium, Tænia echinococcus, and Bothriocephalus latus.

Tænia mediocanellata (Plate III.).—This is one of the commonest and largest tapeworms infesting man, and is very widely distributed. In countries where cattle are badly tended, and where the inhabitants consume imperfectly cooked beef, infection is very common. It is alleged that practically every native in Abyssinia is infected, and that in North-west India a large proportion of the natives suffer from the presence of this tapeworm. In more civilized communities it is far less common, and in this country it is but rarely seen, though when a tapeworm is met with in England, it is usually of this variety. The worm, when fully developed, is from 4 to 8 metres (13 to 26 feet) in length, and possesses over 1,200 proglottides. The head is pear-shaped, and about 1·5 to 2 mm. broad at the widest part. It has neither rostellum nor hooklets, but it possesses four suckers. The eggs are very minute (0·03 mm.), and each contains an embryo armed with six hooklets; the shells are thick and striated. After entering the host, usually a bovine animal, the covering of the egg is digested, and the embryos find their way into the voluntary muscles, where small oval cysts about 1 to 2 mm. up to 1 cm. in length are developed (fig. 2). Occasionally these are also found in the lungs, liver, and brain. A capsule is formed round the cyst (cysticercus), and within the latter is developed the immature cestode, which consists of a caudal bladder in which the head is invaginated. This head is unarmed, but possesses four sucking discs. These cysticerci have not been found in man.

About sixty days after the consumption of infected beef, proglottides of the tapeworm may be found in the stools.

The Cysticercus bovis is said by Perronicito to be killed at

a temperature of 45° C., but probably a temperature of 65° would be required to ensure safety. Thorough cooking, roasting or boiling would therefore destroy the parasite. If infected beef is cut up and placed in brine, or if brine is injected, the cysticerci perish in less than fourteen days. The time, however, depends upon the mass of the meat, and on the strength of the pickling solution. It is more important to note that experiments conducted in Berlin, Dresden, and elsewhere[1] prove that the cysticerci perish if the meat is kept in a cold store for three weeks. The cold is merely to preserve the meat from decomposition, since the cysticerci die at ordinary temperatures within the period named. Cold, however, is not without effect, as by cooling to $-8°$ or $-10°$ C. the worm is killed in about four days. The Cysticercus bovis, or beef bladder worm, must be sought for in the masticatory muscles, the heart, the tongue, the cervical muscles, the muscular portions of the diaphragm, and the intercostal and the thoracic muscles, the actual situation of the cysts being the connective tissue between the muscle fibres. They vary in size, from a pin's head to that of a pea, and are frequently surrounded by inflammatory tissue. The inflammatory process may be sufficient to cause the death of the parasite, and may end in caseation, calcification, or suppuration. The cysts should be distinguished from those of the harmless Cysticercus tenuicollis. The latter are frequently found in sheep, pigs, and cattle, and are the larval form of Tænia marginata of the dog. The cysts vary from the size of a pea to that of a man's fist, and occur most commonly immediately under the peritoneum and pleura, being situated in the underlying viscera, the omentum, mesentery, and occasionally the abdominal muscles and diaphragm. The head of the larval worm is armed with suckers and a double row of hooklets, whilst that of Cysticercus bovis has no hooklets, but possesses four suckers. In both kinds of cyst the head is normally invaginated.

It is customary in this country to condemn a carcass of

[1] Ostertag, *Meat Inspection.*

'measly beef,' and this is no doubt the safest procedure. Apart from the presence of the parasite, however, the muscles often assume a watery character when the invasion is extensive, rendering the meat quite unfit for food.

Tænia solium.—The adult worm as found in the human intestines is from 8 to 12 feet or more in length. The head is very small, however, only about 1 mm. in diameter, but bears a double circle of hooklets, twenty-six or twenty-eight in number, surrounding the rostellum, and four prominent suckers. The fertile proglottides when ripe are discharged, usually with the fæces, and the ova, which are spherical, about 0·03 mm. in diameter, and surrounded by a thick brownish shell with a striated appearance, are transferred to the stomach of a suitable host, especially the pig (possibly also man). The shell is dissolved in the stomach, and the embryo, armed with six hooklets, migrates in some way into the tissues of its host, and more especially into the connective tissue between the muscle fibres. Here, in the course of a few weeks, it forms a delicate, transparent, elliptical cyst, containing a single, spirally coiled, invaginated head (Plate III.) The head possesses twenty-six to twenty-eight hooklets, suckers, and rostellum, thus resembling that of the adult worm. The pig is far more commonly infected than any other animal, and these small cysts or cysticerci are known as Cysticercus cellulosæ, or hog bladder worms. They are from 8 to 10 mm. in length, and the width is about half the length. Pork infected with this bladder worm is spoken of as 'measly.' The consumption of such meat in an imperfectly cooked condition results in the development of the Tænia solium in the intestines. The cysticercus is killed at a temperature of 49° C., and by prolonged pickling in brine. It is more resistant than the 'beef cysticercus,' since after cold storage, even for a period of six weeks, the meat may retain its infective properties. Thorough cooking, however, renders it harmless. Infection with Tænia solium is not nearly so common in Great Britain as in Germany, and in the latter country it is chiefly in the north, where more

partially cooked or uncooked meat is eaten, that the infection is prevalent. The presence of this tapeworm rarely gives rise to any serious disturbance, but the general nutrition may be impaired and anæmia supervene. There is, however, a further danger, since man is also liable to infection by the cysticercus through swallowing the eggs of the tænia, or possibly from some form of auto-infection. The cysticercus develops in the brain (cortex or covering), the eye, the heart, and other organs, rarely in the liver, and only occasionally under the cutis. The symptoms produced vary with the part or parts affected. If the eye, blindness may result; if the heart, functional disturbance or even valvular disease; if the lungs, asthmatic symptoms; if the brain, paralytic or epileptic conditions; and so on according to the organ invaded.

Cysticercus cellulosæ, or the hog bladder worm, resembles the beef bladder worm in size; the cysts are usually located in the abdominal and lumbar muscles, the muscular portions of the diaphragm, the tongue, the heart, the muscles of mastication, the intercostal and cervical muscles, and the gracilis and sternal musculature. They are also to be found in the brain and eye, the lymphatic glands, and the panniculus adiposus. It is only in very extreme cases that the cysts occur in the lungs, liver, and spleen. The disease can sometimes be diagnosed during life by a careful examination and palpation of the tongue. The cysts may undergo similar degenerative changes to those of the beef worm, and they have been found occasionally in sheep, dogs, and deer. In cases of extensive invasion the muscles become greyish-red and watery. The head resembles the scolex of the harmless Cysticercus tenuicollis, to which reference has already been made; the cysts of the latter, however, occur only under the serous coverings of the thoracic and abdominal viscera, the abdominal muscles, and the diaphragm, and the hooklets are more numerous, varying from thirty-two to forty in number.

Measly pork being more dangerous than measly beef, it is the rule to condemn infected carcasses. In Prussia, however,

the fat obtained by rendering or cooking may be utilized unconditionally, and the lean meat may be consumed in the butcher's own family, after having been cut up and boiled under supervision.

Bothriocephalus latus.—This tapeworm is of enormous length, 6 to 16 metres (20 to 50 feet), and may possess 3,000 to 4,000 proglottides (Plate III.). The eggs are extruded before the embryo is formed, and have to lie in water for some time until the six-hooked embryo is developed. In shape they are oval (0·05 by 0·035 mm.), and are provided with an operculum. The embryo is ciliated, and when set free swims about in the water, till it gains access to fish, and finally becomes encysted in the viscera and muscles. The larva (fig. 8), when fully developed, is 1 to 2·5 cm. in length and 2 to 3 mm. broad, and has the head and tail usually invaginated. These larvæ, which are not enveloped in any definite capsule, have been found in pike, eels, trout, grayling, salmon, and other fish. When the raw, smoked, or imperfectly cooked infected fish is eaten by man, or by dogs, cats, and certain other animals, the tapeworm rapidly develops. The chief centres of infection in Europe are the provinces bordering on the Baltic and the districts surrounding the Swiss lakes. In Japan, where fish is largely consumed, it is exceedingly prevalent. In this country very few cases occur, and doubtless the patients become infected abroad. The symptoms caused by the presence of this tapeworm in the human intestine resemble those described under Tænia solium. Any fish in which the larvæ are found should certainly be seized and destroyed. Human infection by the larva does not appear to have been recognized.

Echinococcus or Hydatid Disease is very widely distributed, but it is only in Iceland that any considerable proportion of the population is infected. This is no doubt due to the large number of dogs which are kept in proximity to the huts of the Esquimaux. In England comparatively few cases occur, and it is believed that in Scotland the disease is even rarer. It is not uncommon in the Australian bush.

Kuchenmeister in 1851 first proved that the bladder worms of certain animals were the larval stage of tapeworms, and Von Siebold demonstrated that the Tænia echinococcus (Plate III.) of the dog was developed from the echinococcus cysts of domestic animals. A dog infested with this tapeworm discharges ripe terminal proglottides with the fæces. These soon decay, and the ova being liberated may gain access to a susceptible animal, such as the pig, or to man, by becoming attached to garden produce, or by finding their way into the water supply. The envelope of the ova being dissolved by the digestive juices, the embryos are set free, and in some way gain access to the liver and other organs, and come to rest. Here they develop slowly. According to Verco and Stirling,[1] they at first form 'solid spherical bodies measuring 0·25 to 0·35 mm. in diameter, and bear a striking resemblance to a mammalian egg: that is to say, a thick, homogeneous, transparent, and elastic cuticle or capsule (ectocyst, Huxley) encloses coarsely granular contents, as the zone pellucida encloses the granules of the yolk. In the course of subsequent development the proscolex increases in size, the external envelope becomes distinctly laminated and the contents more transparent, owing to a partial liquefaction. Fluid has, in fact, begun to accumulate in the interior, and the solid mass has become a vesicle with a gradually increasing quantity of liquid. With comparatively slight increase in the size of the vesicle, an internal lining membrane appears upon the inner surface of the cuticle. This constitutes the germinal or parenchymatous layer (endocyst, Huxley). . . The lamination of the cuticle becomes more marked, and remains always a conspicuous and characteristic feature; its thickness increases with age. Meanwhile, even at this early stage, the presence of the growing organism, like other foreign bodies, excites changes in the tissues which harbour it; thus . . . an enveloping capsule of connective tissue is formed, bounding the parasite externally. . . Compared with other forms in the bladder stage, that of Tænia echinococcus undergoes relatively

[1] Allbutt's *System of Medicine*, vol. ii.

slow growth; but even when no more than 15 to 20 mm. in diameter (Leuckart), or sometimes in our experience considerably less, an important development may be already in progress, which still further distinguishes this proscolex from other varieties of bladder worm: this is the formation of numerous heads or scolices.'

Two forms of echinococcus cyst are found in food animals, probably derived from distinct though similar species of Tænia echinococcus. The commonest cyst is the Echinococcus polymorphus or unilocularis (Plates III. and IV.). In this form there are one or more spherical single-celled cysts, surrounded by connective tissue, which may be sterile, or may contain a number of 'daughter' and 'granddaughter' cysts or brood capsules, developed from the parenchymatous layer lining the mother cyst. In food animals the cyst is usually non-fertile, though in sheep it is not uncommon to meet with a number of brood capsules in the interior. Echinococcus cysts of this unilocular character are to be found in sheep, cattle, and hogs, and occasionally in goats. The liver, lungs, and spleen are the usual sites, but the cysts also occur in the heart, kidneys, peritoneum, marrow cavities of the bone, lymphatic glands, udders and muscles. They may within limits be of almost any size, and not infrequently undergo inflammation, caseation, and even calcification. They are usually surrounded by an adventitious capsule of inflammatory origin.

The other kind of echinococcus cyst is the multilocular or alveolar form: in this species daughter cysts are formed *outside* the mother cysts by constriction, and these in turn are furnished with similar reproductive powers. The daughter vesicles become separated from the primary cyst by connective tissue, and, in consequence, the individual vesicles are of no great size, but the whole growth is capable of almost unlimited peripheral expansion, and has some resemblance to an acinous gland; it is from this appearance that it derives its name, Echinococcus alveolaris. This species is comparatively uncommon, and chiefly affects the liver of bovines, though it

has been found in sheep and hogs. In the liver it resembles actinomycotic granulations, the central portion being usually caseous and even calcareous, whilst, when it affects the structures beneath the pleura, it is almost indistinguishable to the naked eye from perlsucht. On microscopical examination, however, the cysts at the periphery of the growth will be found to be echinococcal in nature.

Unless a cyst is sterile or has undergone secondary changes, the fluid when examined under the low power of a microscope will show a large number of scolices. They should be looked for in the liver, lung, and spleen, kidneys, and lymphatic glands. The smallest cysts will easily be visible to the naked eye, but their character may not be immediately recognizable. The larger ones present no difficulty, but the smaller may resemble those of Cysticercus bovis or cellulosæ. In the latter, however, each cyst contains only a single cestode head, instead of the numerous scolices attached to an echinococcus cyst, and the situation and character of the contents should be sufficient to make the distinction easy. Even when caseation has occurred the cysts are distinguished from tubercle by the lamellar arrangement of the wall, and the freedom from infection of the lymphatic glands.

Any organ containing echinococcus cysts should be carefully destroyed, to avoid the danger of infecting dogs. The flesh of the infected animal, if normal, may be passed as being wholesome.

The Echinococcus veterinorum (Plate IV.) sometimes found in the encysted form in the liver of the ox is harmless to man, nevertheless such an infected organ is better destroyed.

Very many other tapeworms infesting animals are known, but with very rare exceptions the above are the only ones affecting man, and therefore requiring special consideration. Animals infested with other forms may be considered as not endangering the health of those consuming the flesh, but few people would care to eat the flesh of animals containing the larvæ of any kind of tapeworm. Cysticerci are often found also in

rabbits, hares, &c. (Plate IV.), but as they are apparently quite harmless to man they are rarely sought for, and if observed the animals could not legally be seized.

Other parasites which, whilst not necessarily infecting man, may cause the flesh or organs of an animal to be unfit for human food, are Distoma (liver-flukes), various round worms, Pentastomum tænioides, and various forms of protozoa.

Distoma.—The flukes are trematode worms, and two of them, Distoma hepaticum and Distoma lanceolatum (Plate V.), are important on account of their frequent occurrence in cattle and sheep. Occasionally they are found in pigs, and in rare instances they have been found in man. The ovum gives rise to an embryo, which, when deposited on a suitable pasture, is believed to attach itself to a water-snail, within the body of which it undergoes a number of developmental changes (sporocyst, redia, cercaria), the final form passing out of its intermediate host and becoming encysted on a blade of grass, until it enters the stomach of a sheep, when the fluke develops.

The Distoma hepaticum is a flat, obovate worm, from 15 to 40 mm. long and 4 to 12 mm. wide. It has an oral sucker and buccal orifice. Behind the latter is the ventral sucker and the genital aperture. The surface is covered with fine scale-like spines projecting backwards. Flukes are chiefly found in the bile ducts, but may migrate in numbers into the lungs. In sheep they give rise to the disease known as 'sheep rot,' the symptoms of which are emaciation, dropsy, and enlargement of the liver. The disease is often fatal, and chiefly attacks flocks pastured on marsh land where water-snails abound.

Distoma lanceolatum is smaller than the D. hepaticum, and, as its name indicates, it is lanceolate in outline. In sheep it, as a rule, gives rise to no serious illness. Any organ at all extensively affected by the parasites of this group is usually destroyed, and in the case of advanced invasion by liver-flukes it may be necessary to condemn the whole carcass owing to the œdematous condition of the flesh which ensues. There

is usually no difficulty in recognizing their presence; they lie in the bile ducts, which become enlarged, the walls being thickened and their lining membranes 'gritty' to the touch. The thickening of the bile ducts is often apparent on the surface of the liver, giving rise to streaks and lines.

The flukes may occasionally be found in the lungs.

Many other distomes have been found in animals, but they rarely occur in this country. A fluke has been detected in the muscle of the pig, but on a few occasions only.

Round Worms.—The Echinorynchus gigas, a round worm of enormous length which infects the pig, may cause inflammation of the bowels or even peritonitis. The ascaridæ are often found in abundance in the intestines and may cause emaciation. Occasionally they penetrate into the bile duct, and may then give rise to jaundice. Strongylus contortus, or the palisade worm, lives in the fourth stomach of the sheep (and goat), deriving its support from the blood of its host; hence young animals may become emaciated from the presence of an abnormal number of these worms. Other species of strongylus infect sheep and cattle, some being located in the stomach, other varieties selecting the lungs. Strongylus paradoxus is very common in the lungs of pigs, the invasion usually being restricted to the bases,[1] causing bronchitis and bronchiectasis. The inflammatory reaction caused by the presence of strongylidæ in the lungs may give rise to an appearance resembling tuberculosis. The glands, however, will be free from tubercle, and a microscopical examination will make the diagnosis clear.

Pentastomes (N.O. Arachnoidea) are only of interest on account of the larvæ, which, after becoming encysted, may caseate and resemble tubercle, especially when the lymphatic glands are affected. They are found in the viscera of cattle, sheep, pigs and other animals, and are flat, white, translucent bodies about 4 to 5 mm. long and 1·2 mm. broad, having about 80 segments, each furnished with numerous fine

[1] Ostertag, *op. cit.*, p. 414.

bristles. At each side of the oral aperture are two other apertures, from which minute claws protrude. The larva may become surrounded with pus cells, or caseate, or calcify. In the liver and spleen the larvæ are encapsuled, but apparently not so in the lymphatic glands. Butchers' dogs are chiefly infested with this larval pentastome, the sexually mature form of which is 8 to 20 mm. long, and occurs in the nasal cavities of the dog, horse, and other animals. The larval form has frequently been found in man, doubtless derived from eggs deposited in the fæces of dogs. Apparently its presence produces no recognizable symptoms.

The larvæ of the Pentastoma denticulatum (Plate V.) may be sought for in the mesenteric glands of cattle, sheep, and pigs, where they form yellowish green or grey nodules, varying in size from a millet seed to a pea. A low power of the microscope is necessary for identification. Even when the foci have become caseous the claws may be discovered; though somewhat resembling the hooklets of cysticerci, they are easily distinguished therefrom. If found in the mesenteric glands, the liver and lungs should be examined, or, preferably, the whole of the viscera should be carefully destroyed. The flesh of the animal is not affected.

Protozoa. — Coccidia, myxospondia, sarcosporidia and hematosporidia are protozoa, certain species of which infest animals. Coccidia are unicellular organisms chiefly affecting epithelium. The C. oviforme (Plate V.) is frequently found in the lining of the bile ducts of rabbits, and has been detected in the liver of man. This or an allied form also attacks the liver of pigs. To the naked eye the appearance resembles tubercle, but by squeezing some of the fluid from the organ infected upon a slide, or by cutting sections, the coccidia can readily be distinguished under the microscope. Each organism is surrounded by a capsule oval in shape, and with a double contour; the length varies from 30–40μ and the breadth from 15–20μ. C. perforans appears to attack the mucous membrane of the intestines of sheep and calves. Another

species is believed to be the cause of red dysentery, a disease which invades young cattle in certain parts of Switzerland. Chicken-pox of fowls, a disease of the mucous membrane and general integument of the head and neck, leading to wart-like growths and diphtheroid membranous formations, is probably caused by coccidia. Myxosporidia give rise to tumours on the bodies of fish, the spores becoming surrounded by fibrous cysts. The so-called Miescher's sacs (Plate V.), which consist of small membranous sacs containing round or oval cells, and often found within the striated fibres of the skeletal muscles of the pig, sheep, and other animals, are regarded as sarcosporidia. The sacs vary from 0·04 to 0·5 mm. in length and from 0·006 to 0·4 mm. in breadth, and are often found calcified. They are exceedingly common in the pig, and are chiefly of interest on account of the ease with which they may be confounded with trichinæ. So far as is known their presence has no significance, and does not render the flesh unwholesome. The organs of animals infested by coccidia or myxosporidia should be destroyed. Hematosporidia are microscopic protozoa found in the red blood corpuscles of the animals suffering from Texas fever. They are introduced into the blood by means of ticks. The flesh of an animal suffering from this disease would probably be quite unfit for human consumption.

Trypanosomata are flagellate infusoria. In the case of Nagana, so common in South Africa, the parasite is introduced into the blood by the bite of the tsetse fly. They are two or three times as long as a red blood corpuscle, fish-like in form, and actively motile. Infected animals either quickly succumb, or die after some months in an emaciated condition. Such animals are often slaughtered and appear to be eaten with impunity. Other examples of trypanosomiasis are furnished by Surra disease and piroplasmosis.

In the accounts given of the various diseases which may render the flesh of animals unfit for human consumption, the parts most likely to be affected and more especially requiring examination have been indicated. Particles selected for

microscopical examination should be dissected out, placed in glycerine and examined under a magnifying power of about 100 diameters. If this fails to show the structure when gently pressed between the slide and cover slip, the particles may be treated with warm 5 per cent. solution of caustic potash, or with glacial acetic acid. Where there is much fat a preliminary treatment with ether is desirable. After treatment the particles can be mounted in glycerine. When sausage or potted meat is being examined very thin slices should be taken from different parts, cleared with ether, alkali or acetic acid, and mounted in glycerine.

CHAPTER XX

UNSOUND FOOD (*continued*). FISH

Cases of food poisoning due to fish, or of disease of any kind communicated by fish, are comparatively rare in this country. During recent years, however, many cases of typhoid fever have been traced to the consumption of shell-fish taken from polluted sources, and it has been suggested that other fish may be specifically infected, and if imperfectly cleansed and cooked, be capable of causing typhoid fever. On two occasions within recent years limited outbreaks of this fever have been attributed to the consumption of fried fish, but on neither occasion was it possible to say how the fish became infected.

As already mentioned, the larval form of Bothriocephalus latus is parasitic in certain fish, and is capable of giving rise to the adult tapeworm in man. Fortunately such cases in this country are rare.

The chief class of disease, however, caused by the consumption of fish is that generally known as ptomaine poisoning. Brieger has separated trimethylamine, dimethylamine, methylamine, and the alkaloidal bodies neuridine, cadaverine, and putrescine from decomposing fish, all of which are poisonous in varying degree, and possibly to the formation of some of these bodies may be ascribed the toxic symptoms produced by fish which is not perfectly fresh; but the subject of poisoning by such products of decomposition will be dealt with in a separate chapter. It will suffice to say here that the symptoms produced by decomposing fish are similar to those induced by flesh under similar circumstances, but are more frequently associated with a rash, generally urticarial in character, and

frequently accompanied by intense irritation. The rash may subsequently be followed by desquamation, or desquamation may occur without any rash being noticed.[1]

Stale fish is notoriously liable to cause nausea, vomiting, and diarrhœa, but fortunately the odour of fish which is becoming 'stale' is usually so pronounced that the condition is easily recognizable. The early signs of decomposition, besides alteration in smell, are loss of brilliancy in colour, excessive drooping of the tail when the fish is held in the hand, loss of sheen in the eyes, cloudiness of the cornea, pallor of the gills (these may occasionally be painted with blood by an unscrupulous vendor), softness of the muscles which pit on pressure, and looseness of the scales. In stale fish the appearance of the eyes may be fraudulently improved by the introduction, behind the eye-ball, of a pointed piece of wood. This increases the tension of the eye-ball and pushes it forward. Fresh fish will sink in water, but when decomposition has set in they will float. During the spawning season fish are said to be naturally flabby and to be unfit for human food; and, according to Andrews, the livers of otherwise wholesome fish have been known to give rise, when eaten, to severe gastro-intestinal disturbance, followed shortly by a red rash, and later on by desquamation.

The odour of decomposition can best be detected in the gills, and if this odour is pronounced the fish cannot be said to be fit for human consumption.

It is not so easy to tell by external appearance when shell-fish begin to be unfit for food. In the case of lobsters and crayfish the tail remains curled beneath the body so long as the fish is fresh, and when sliced, the fish should have its characteristic odour. Crabs must be opened so that the odour of the contents of the carapace may be ascertained, and unless perfectly sweet they should be condemned.

Cockles, mussels, and oysters should have their shells firmly closed when taken out of water, and if in water the open shell should close when touched. When a marked proportion of the

[1] *Lancet*, 1904, i. p. 1,653.

shells show a tendency to gape, and the shells of others are easily separated, the batch should be considered as unsound and unfit for food. In such cases the bodies of the fish will be found to be unusually soft, and to have acquired an odour different from that of a fresh fish.

When in a fresh and healthy condition the winkle is not readily detached from its shell. If easily detachable, and having an unpleasant odour, the batch is probably unfit for food and should not be exposed for sale.

Occasionally oysters are exhibited for sale the branchia and labial palps of which have a green colour. Oysters from diverse sources develop this colour under certain unknown conditions, whilst in some localities the oysters are almost invariably thus coloured. They are usually spoken of as green-bearded, and regarded as unfit for food, but this opinion is probably erroneous, as on parts of the French coast the oysters are not considered fit for the market until they have become green. It is not at all certain that this 'greening' is always due to the same cause. In some cases it is apparently derived from a pigment allied to chlorophyll, whilst in others it may be due to copper. Thorpe has certainly shown that the green oysters of Cornwall contain more of this metal than the colourless ones. It may, however, be that a trace of copper in the water over the layings helps to fix the green colouring of the algæ upon which the mollusc feeds. The green Falmouth oysters were found by Thorpe to contain 0·023 grain of copper each, whilst the white variety only contained 0·0062 grain. Whatever the cause of the greening, there is no reason for regarding such oysters as unwholesome.

Until recently neither oysters nor cockles had received much attention as possible causes of ill-health amongst those who consumed them, whilst mussels appear to have been looked upon as a dangerous article of food from time immemorial. The symptoms of mussel poisoning vary so much that it is doubtful whether all the cases of illness following the eating of mussels are due to one and the same cause. Possibly

when polluted by sewage, or when undergoing incipient putrefaction, they may give rise to gastro-intestinal disturbance, vomiting and diarrhœa, as in the case of other shell-fish; but some other cause must be assigned for the illness produced by fresh mussels, an illness unlike that caused by other shell-fish, and almost consistent with that of poisoning by curare. In these cases, the diarrhœa, vomiting, and epigastric pain are followed by an urticarial rash, swelling of the tongue and fauces, together with swelling of the eyelids and symptoms of coryza. There may be great prostration, tingling of the lips, dryness of the throat, loss of muscular co-ordination or even complete paralysis. Death not unfrequently ensues, the mind remaining clear to the end. In some epidemics diarrhœa has been entirely absent, the abdomen being greatly distended and tympanitic. In a few instances mussels from polluted sources are believed to have caused typhoid fever, but the evidence is not as conclusive as in the case of oysters and cockles. One of the earliest recorded outbreaks of mussel poisoning occurred at Leith in 1827, when some thirty persons were attacked, two of whom subsequently died. A dog and a cat which had partaken of the mussels were also affected. The shell-fish had been detached from the dock gates, and Dr. Christison evidently thought the poisonous effects might be due to copper, as he examined the mussel from the stomach of one of the patients for that metal, but was unable to detect it. In 1885 an outbreak occurred at Wilhelmshaven, a number of persons who had eaten mussels taken from the bottom of two vessels anchored in the port being attacked, four dying. The illness commenced nineteen hours after the mussels were eaten, and some animals which had been fed on the same mussels quickly succumbed. It was from the livers of these mussels that Brieger isolated a ptomaine which he named mytilotoxine, from the name of the edible mussel, Mytilus edulis. Later Dutestre found that the alkaloid extracted from the liver of poisonous mussels had properties similar to those of curare. Dr. Bulstrode, in his report on oysters and other shell-fish

('L.G.B. Report,' 1894–5), referring to these and other recorded outbreaks, discusses their possible cause. The popular impression that the poison is contained in the branchiæ or gills is disproved by the fact that mussels, from which the gills have been removed, have caused symptoms of poisoning. The 'copper' theory is likewise untenable, and there is no evidence to prove that the poison is only produced during the spawning season. It seems probable that mussels are capable of causing two distinct forms of poisoning, one due to the development within the animal, possibly by bacteria, of a ptomaine, mytilotoxine, the other due to the presence of bacteria derived from sewage-polluted water, exactly as with sewage-polluted oysters and cockles.

The first outbreak of disease attributed to oysters of which we can find any record is one which occurred in France as far back as 1816. Cases of illness occurred in several towns following upon the consumption of oysters taken from a laying exposed to gross pollution. In 1880 Sir C. Cameron attributed some cases of typhoid fever to the eating of sewage-polluted oysters, and in 1893 Dr. Bulstrode expressed his conviction that the distribution of shell-fish from Cleethorpes and Grimsby had been concerned in the diffusion of scattered cases of cholera over a somewhat wide area of England, and that these shell-fish were so deposited and stored as to be almost necessarily bathed each tide with the sewage from different sewers at that time receiving cholera discharges. In 1894 Dr. Newsholme described some cases of typhoid fever which he attributed to sewage-polluted oysters. Attention thus being called to the subject in England, cases were frequently reported of illness following the consumption of oysters, cockles, and occasionally other shell-fish. Many such cases happened in Essex, and invariably the oysters or cockles were traced to sources which were notoriously liable to sewage pollution. In 1894 occurred the serious outbreak of typhoid fever at the Wesleyan University, Connecticut, U.S.A., during which twenty-six persons who had attended a certain fraternity supper were attacked. The

only article of food which had been partaken of by all was oysters, and these were found to have been derived from a creek receiving sewage from the outlet of a drain within 300 feet of the layings. At the house connected with this drain were two cases of typhoid fever, so that the sewage at that time was specifically infected. In 1896 Dr. Chantemesse reported an outbreak in the town of Saint André-de-Sangonis. A barrel of oysters was consumed by fourteen persons and all were taken ill, other members of the same household not being affected. All appear to have been attacked with vomiting and diarrhœa, and two suffered from a severe type of typhoid fever. It was afterwards found that these oysters had been stored in grossly polluted water. In 1902 occurred a series of cases of typhoid fever following the Mayors' banquets at Winchester and Southampton, which were investigated by Dr. Bulstrode for the Local Government Board. Out of 134 guests at the Winchester banquet sixty-two were attacked with illness of some kind or other, and at Southampton out of 132 guests fifty-four were taken ill, and nine of the former, and ten of the latter suffered from typhoid fever.[1] Dr. Bulstrode summarizes the results of his observations as follows:

1. Two mayoral banquets occur on the same day in separate towns several miles apart.

2. In connection with each banquet there occurs illness of analogous nature, attacking, approximately speaking, the same percentage of guests and at corresponding intervals.

3. At both banquets not every guest partook of oysters, but all those guests who suffered from enteric fever, and approximately all those who suffered from other illness, did partake of oysters. The exceptions to this rule appear insignificant when all the facts are marshalled.

4. Oysters derived directly from the same source constituted the only article of food which was common to the guests attacked.

5. Oysters from this source were at the same time and in

[1] *Local Government Board, Report of Medical Officer.* 1902-3.

other places proving themselves competent causes of enteric fever.

The presumption that the oysters were the cause of the illness amounts, therefore, to a practical certainty. In 1895 Dr. Bulstrode had pointed out the dangerous proximity of the layings, from which these oysters were taken at Emsworth, to the sewer outfalls, and previous to the outbreak cases of typhoid fever had occurred at Emsworth. Considering that this disease had been prevalent nearly every year in the town, it is difficult to explain why similar outbreaks had not previously occurred; but our inability to explain this does not in any way weaken the evidence against the oysters; it merely reveals our ignorance of all the concomitant conditions necessary to so infect an oyster as to render it capable of causing typhoid fever, or illness of an allied nature. In 1902 one of us investigated an outbreak, including four cases of typhoid fever and twenty-one other cases of illness, which occurred in August of that year at Mistley, Essex. The oysters implicated were what are known as 'Portuguese,' and were sold from a fishing smack at various places. In a few instances only did the sickness and diarrhœa supervene within a few hours. In most cases the illness commenced from twenty-four to forty-eight hours after eating the oysters, suggesting infection by some such organism as the B. enteritidis of Gärtner. The illness varied from a feeling of nausea and distressing weakness to a fatal attack of enteric fever. Only a certain portion of the oysters sold appears to have been capable of causing illness, all the cases occurring amongst those who purchased oysters from the smack whilst it was anchored at a certain place near a sewer outfall. Those which were sold at other places where the smack put in apparently produced no ill effects. We afterwards examined the layings from which the oysters were obtained but could detect no source of pollution. The smack owner denied having used any of the sewage-polluted water at Mistley for refreshing the oysters. The oyster merchants accounted for the illness by saying that the oysters were

probably sick, and one or two persons who suffered said that the oysters looked yellow or had an unusual taste. The true native oyster (Ostrea edulis) is hermaphrodite, and spats from May to September. It is illegal to remove them for the purpose of sale from May 14 to August 4. The Portuguese oyster (Ostrea angulata), on the other hand, is unisexual and is said never to show the signs of 'sickness' observed in the native oyster during the close season. Even the assumption that a 'sick' or spawning oyster is unwholesome does not explain why a certain few sold at a certain time and in a certain place should cause diarrhœa, sickness, and typhoid fever. At present, therefore, the cause of the unwholesomeness of the oysters remains undiscovered.

In nearly all the carefully recorded cases where shell-fish has caused typhoid fever other persons have suffered from diarrhœa, sickness, &c., and in our experience of Essex cases, those who are earliest attacked with diarrhœa are most likely to escape an attack of typhoid fever, and *vice versa*.

The case against cockles is perhaps not quite so conclusive as that against oysters, since this humble bivalve does not appear on the menu at mayoral banquets, being consumed entirely by persons of the poorer class. Moreover, they are usually cooked before eating, but though the process of parboiling to which they are subjected in the homes of the poor may possibly sterilize the outside of the animal, it certainly has little if any effect upon the stomach contents.[1] At Leigh-on-Sea, the chief centre of the cockle industry in the south of England, the cockles are now submitted to steam under pressure for a certain length of time, but since this process has been introduced cases of typhoid fever have to our knowledge been attributed to cooked cockles purchased there. One of us has investigated several outbreaks of typhoid fever in Essex, in which the disease was limited to persons who had partaken of certain cockles picked from polluted foreshores. In 1889 an outbreak occurred at Exeter amongst children who had visited

[1] See also *Report of Medical Officer to the Local Government Board*, 1900–1.

Exmouth in connection with school treats, and who had eaten freely of 'raw' cockles from sewage-polluted mudbanks. Many medical officers of health have since reported cases of typhoid fever which they had reason to believe were due to the eating of cockles. In all these instances, where the source from which the cockles were taken was examined, the pollution by sewage was more or less gross and unmistakable. An examination of the bacterial contents of these bivalves shows that they almost invariably contain the Bacillus coli; we have searched for this organism in samples taken from the reputedly safest known source round the coast, and have had no difficulty in isolating it from the body pulp.

So far as we are aware, the only occasion on which the Bacillus typhosus has been detected in cockles suspected of causing disease was connected with an outbreak of enteric fever which occurred in Glasgow in 1903. The patients were Glasgow people who had been holiday-making at a neighbouring seaside resort. The occurrence was investigated by the Scottish Local Government Board in conjunction with Dr. Knight, and it was found that, in addition to the actual cases of typhoid fever, many other persons were attacked with vomiting and diarrhœa, apparently due to the same class of food. As already pointed out, this is the rule in epidemics of typhoid fever due to shell-fish. It is also noteworthy that the gastro-intestinal symptoms occurred within a few hours of eating the shell-fish, whilst in many of the persons who contracted typhoid fever no early symptoms appeared. Samples of cockles and 'muskins' were collected from the suspected locality, which was known to be polluted by sewage, and the Bacillus typhosus was isolated by Buchanan from four cockles and one muskin, the Bacillus coli in these particular samples being comparatively few in number. From a loopful of the fluid from one of the cockles it was estimated that no less than 7,000 colonies of B. typhosus were obtained.[1]

[1] *Journ. Royal San. Inst.* xxv. part iii. p. 463.

The only univalve mollusc which is largely used is the periwinkle (Littorina littorea). Although, when sold in towns, it is usually boiled before being eaten, it is not uncommon for excursionists and even residents near the coast to pick them up from the shore, abstract the bodies from the shells, and eat them 'raw.' Considering the localities from which some of the winkles are gathered, it is certainly curious that no illness appears to have been recorded as arising from eating them.

In a recent report to the Fishmongers' Company Dr. Klein gives an account of some interesting experiments made by him with reference to the vitality of the bacillus of typhoid fever and of sewage microbes in oysters and other shell-fish. He found that native oysters, whether from a polluted or unpolluted source, after being placed in sea-water infected with very large numbers of the Bacillus typhosus, freed themselves from the presence of this bacillus in from six to nine days if transferred to clean sea-water. When placed in sewage-polluted water and similarly transferred he found the Bacillus coli disappeared with equal rapidity. This we have had occasion to confirm.

On the other hand, cockles did not exhibit this tendency, the bacilli actually multiplying in the body of the animal for a time. In mussels the bacilli did decrease in number, but were still very plentiful after seven days' immersion in clean sea-water. It is fortunate, therefore, that these latter shell-fish are so rarely eaten without being cooked, and the necessity for thorough cooking is emphasized.

Caviare consists of the roe of certain fish, usually the sturgeon, which has been specially treated to suit the market for which it is intended. It is generally imported in casks, and is then packed in small sealed bottles, jars, or tins, for sale. No one but an expert would venture to give an opinion upon the quality or condition of this substance. It varies greatly in colour, in consistency, and in odour, the latter being to many people at all times offensive. Cheese may be kept until it acquires a very strong odour, and in this condition be esteemed

by some as a great delicacy, whereas by others it would be considered as rotten and unfit for food. In the same way differences of opinion may arise with reference to caviare. It may, however, become rancid, or acquire a mouldy taste, in either of which conditions it would be unsaleable and possibly unfit for food. If preserved in hermetically sealed vessels, these when opened under water should not give off bubbles of gas with a distinctly offensive odour. Some caviare which had been sent to South Africa, and returned after the war, was examined by one of us. Nearly all the tins (each of which contained 4 ounces) were blown, and when pricked under water gave off from 2 or 3 to 20 c.c. of an inflammable gas with an offensive odour, and the contents were found to have become softer than usual, tending to become pasty. The caviare was regarded as being unfit for food.

CHAPTER XXI

BACTERIOLOGICAL EXAMINATION OF SHELL-FISH, OYSTERS, COCKLES, ETC.

THE unenviable notoriety which oysters (and cockles) have attained during recent years has led to many attempts being made to discover some method of examination which would reveal whether the shell-fish exhibited signs of sewage contamination. Shell-fish have been seized in the City of London upon the results of bacteriological examination, but unfortunately no case has been contested in the Courts, and the legality of this procedure, based merely upon the results of such an examination, has not been decided. The Royal Commission on 'Disposal of Sewage' express the opinion that section 116 of the Public Health Act is useless for preventing the sale of contaminated shell-fish. 'There is nothing,' they say, 'in their appearance to distinguish shell-fish which have been exposed to sewage contamination from those which have not been so exposed, and . . . in the present state of knowledge it would be impracticable to make the distinction by the aid of a bacteriological examination as a routine measure.' Dr. Klein had expressed the view that the normal oyster does not harbour within its shell or within its body Bacillus coli communis or other organisms closely allied to it, and that the presence of these organisms 'in considerable numbers of oysters in a series of samples from a particular locality may be taken to indicate sewage pollution.' On the other hand, one of us pointed out to the Commissioners that the Bacillus coli was commonly present in cockles and oysters taken from layings remote from

the possibility of sewage contamination. Dr. Houston was therefore instructed to examine a large number of oysters from (*a*) the purest waters in which oysters are grown or fattened in this country, and (*b*) from layings obviously liable to pollution. The results showed that nearly all the oysters examined (over 1,000), from whatever layings they were taken, contained Bacillus coli communis or other bacilli closely allied to it. Moreover, he found—and this has been repeatedly confirmed by one of us—that the number of organisms belonging to the coli group obtainable from the contents of the stomach of the oyster was greater than that from the liquid contained in the shell. Observers who have confined their attention to the liquid only have failed repeatedly to isolate the Bacillus coli from oysters taken from admittedly polluted layings. The mere presence of the Bacillus coli in an oyster is therefore no proof of its being derived from a polluted source, and the same applies to the presence of the Bacillus enteritidis sporogenes and streptococci. The reason for this is not difficult of explanation, and it is surprising that no reference is made to it in the Report of the Royal Commission. All the noted oyster layings in this country are situated near extensive tracts of marshes, from which the ditches pour out on the foreshore vast volumes of water charged with organic matter in solution, and swarming with low forms of vegetable and animal life. It is probably this condition which renders such localities so eminently suited for breeding and fattening oysters. These waters contain an abundance of organisms of the coli group, and also of the Bacillus enteritidis sporogenes. The marshes are practically uninhabited, but large numbers of cattle may be fed upon them. In a tidal river recently examined by one of us, the most careful examination failed to reveal any trace of sewage entering the stream, yet the Bacillus coli was found both in the river-water and in the oysters taken from the layings, and, in the latter, in rather large relative abundance. Finally it was found that water was entering from a marsh ditch near the layings, a ditch which received no sewage, but

merely water draining from the marshes and containing an abundance of the Bacillus coli. There is no doubt that organisms of this type form no essential part of the bacterial flora of deep-sea water, but they appear to be an essential part of the flora of waters suitable for fattening oysters.

Whilst directing attention to the danger of attaching too much importance to any standard, Dr. Houston suggests tentatively two standards, one 'stringent' and the other 'lenient,' based on the collective examination of ten oysters made on the lines suggested in his report.

Oysters containing less than 100 coli-like microbes per oyster, and less than ten spores of the Bacillus enteritidis sporogenes, would pass the 'stringent' standard, but if containing above this number, but less than 1,000 coli-like microbes, and 100 spores of the Bacillus enteritidis sporogenes, they would pass the 'lenient' standard. Oysters containing organisms in excess of the 'lenient' standard he regards as 'outside the pale of recognition.' A coli-like microbe he defines as one which produces acid and gas in litmus-glucose-taurocholate broth, grows on gelatine with the characteristic appearance of the Bacillus coli, and gives three out of four of the following reactions: fluorescence in neutral-red broth, acid and gas in lactose-peptone solution, indol in peptone solution, and acid-clotting of milk. He finds that about 85 per cent. of the coli-like organisms give the whole of the four reactions. It follows from what has been above stated that he would be a bold man who would dare to condemn oysters (and therefore the layings from which they were taken) from a mere bacteriological examination. The examination of sources from which oysters producing disease have been taken, and a study of the description of other such sources, leads us to the conclusion that, in all the cases in which oysters have caused typhoid fever, the layings from which they were taken were grossly and obviously polluted by human sewage, and when oysters are known to be derived from such a source probably their seizure would be justifiable.

From what has been said it is obvious that great care must be exercised in arriving at a conclusion as to whether shell fish are dangerously sewage polluted from a mere bacteriological examination. This applies more especially to oysters which are fattened and bred on the foreshores of estuaries. The mere fact that certain bacteria are present in the liquid within the shell or in the body of the fish is no proof of sewage contamination, but if they are present in large numbers there is presumptive evidence of such pollution. Two methods of examination have been adopted. In one a number of separate oysters (or cockles) are examined individually, the liquid in the shell of each being examined for the presence of the two bacteria above-mentioned, and the liquid which exudes when the body of the fish has been cut nearly through being similarly examined. If in a considerable proportion of these, say 30 to 50 per cent., the two bacteria are found, the shell-fish are considered as being derived from an unsafe source. The experience of one of us with this process is that it is less reliable than the alternative process, which consists in cutting up the bodies of say ten of the oysters or cockles, forming these into an emulsion with the liquid from the shells, diluting with water and examining the mixture, taking portions of the liquid corresponding to an aliquot part, or the whole, of the contents of one pair of shells.

The shells must be thoroughly scrubbed in running water with a nail-brush (the use of a little soap is recommended by Houston), and then well rinsed with sterile water, and laid out on a sterile plate with the flat shell upmost. The hands of the operator should then be sterilized by any ordinary process, and rinsed with sterile water. Each oyster grasped in a sterile towel is then opened with a knife, and a little experience is required in order to do this expeditiously and without losing any of the liquid out of the shell. The liquid is poured into a litre cylinder, and the oyster taken up by means of forceps and cut up with scissors, the fragments being allowed to fall into the cylinder. When ten oysters have been thus treated, they

are well mashed up with a glass rod expanded at the end. The rod, scissors, &c., should all have been recently sterilized. Sterile water is then added to 1 litre and the whole well mixed. One hundred c.c. equal the contents of one oyster, 10 c.c. $\frac{1}{10}$ of an oyster, 1 c.c. $\frac{1}{100}$ of an oyster, and dilutions should be made so that 1 c.c. corresponds to $\frac{1}{1000}$, $\frac{1}{10000}$, and $\frac{1}{100000}$ respectively, of an oyster. These solutions are then used for the tests for the Bacillus coli and Bacillus enteritidis sporogenes. Houston recommends that three primary cultures should be made with each, and the result considered negative unless the characteristic reaction is obtained with at least two out of the three.

For detecting the Bacillus coli communis use bile-salt-lactose-litmus broth for the primary cultures. From the tubes in which fermentation is set up, inoculate bile-salt-lactose-neutral-red-agar plates, and from the colonies surrounded with haze, if any, inoculate milk (for acid and curd), peptone solution (for indol), and gelatine tubes (for non-production of liquefaction). Examine also in a hanging drop, and stain the bacilli by Gram's method. If positive results are obtained throughout, the presence of the true Bacillus coli may be considered to be demonstrated. If either the milk is not curdled or indol produced an allied organism may be present of the coli group, but the presence of the Bacillus coli communis cannot be asserted. If the organism liquefies the gelatine it is probably a proteus, it is certainly not one of the coli group (*vide* Thresh, 'Examination of Water,' p. 352).

For detecting the Bacillus enteritidis sporogenes, a series of tubes of recently boiled and cooled milk are used, and each mixture incubated anaërobically (*op. cit.*, p. 356). The characteristic 'enteritidis change,' if found in two out of three of each series from the same dilution, may be assumed to indicate the presence of the spores of this bacillus in the amount of the liquid used.

When both the true Bacillus coli and the spores of the B. enteritidis sporogenes can be found in $\frac{1}{100}$ of an oyster by this

method, it is probable that the batch comes from a contaminated source, as we have never found oysters from a source which upon examination could be considered satisfactory to give such high results, but oysters taken from the best layings round the coast have been repeatedly found by one of to us contain both organisms in $\frac{1}{10}$ of the shell contents, but never in $\frac{1}{100}$. Houston's suggested tentative standards based on the average number of coli-like organisms and of spores of the Bacillus enteritidis sporogenes in each oyster, which differ slightly from the above, have already been given. His views will be found at length in vol. iii. of the 'Fourth Report of the Commission on the Disposal of Sewage,' pp. 169–72.

Cockles, mussels, and other shell-fish may be examined in a similar manner, but there are no records which enable us to suggest even a provisional standard. One of us has failed to obtain from any source cockles which did not contain the Bacillus coli. The question, however, is one of comparatively little importance, since cockles and mussels, unlike oysters, are only consumed after being cooked. Although this process, as ordinarily conducted, does not sterilize the interior of the bodies, it must considerably reduce the risk to those who consume them.

The method adopted by Klein[1] in examining oysters (and other shell-fish) gives results which differ considerably from those obtained by Houston's, though why this should be so is difficult to explain. Klein relies entirely upon the examination of individual oysters to ascertain the proportion in which the Bacillus coli is contained, and upon the approximate estimation of the number found in each. For this purpose he strongly recommends the use of the Drigalski-Conradi medium (nutrose-litmus-lactose-crystal-violet agar), which not only permits of the Bacillus coli being readily isolated, but also gives typical colonies of the Bacillus typhosus, and the Bacillus enteritidis of

[1] *Experiments and Observations on the Vitality of the Bacillus of Typhoid Fever and of Sewage Microbes in Oysters and other Shell-fish*, by E. Klein, M.D., F.R.S. The Worshipful Company of Fishmongers, August 1905.

Gärtner when these are present. The following account of the method followed by him in his recent investigations for the Fishmongers' Company is taken from his interesting and valuable report:

'The oyster, after the outside of the shell had been thoroughly washed and brushed under the tap, was opened with a sterile knife, the liquor was drained off as completely as possible, the body of the fish, with its mantle and branchiæ, was then transferred to a sterile glass dish, and herein cut up (minced) with sterile scissors as finely as possible; after thoroughly mixing the minced material, the fluid (thick, turbid) is removed with a sterile glass pipette and measured. From this fluid a definite amount, in no case more than 0·1 or 0·15 c.c. was . . . directly transferred to a Drigalski plate. . . . After having by means of the sterile bent glass rod carefully, thoroughly, and uniformly rubbed the material over the surface of the dry medium (all previous moisture having been previously removed by allowing the plates to evaporate it spontaneously for two to three hours in the incubator), the plates are transferred to the incubator at 37° C.'

Two or more plates may be made from each oyster if so desired. On the Drigalski medium at 37° C., the B. coli of fæcal matter, after twenty-four to thirty-six hours, gives colonies several millimetres in diameter, distinctly red, with distinct red halo when viewed in transmitted light. Such colonies are picked out for further examination and are not regarded by Klein to be the true B. coli unless they correspond to all the following tests:

1. Give numerous gas bubbles in nutrient gelatine shake-culture in twenty-four hours at 20° C.

2. Give on a gelatine slope, from a streak, at 20° C. a rapidly spreading dry band with irregular margin; no liquefaction of gelatine at any time.

3. Give a greenish fluorescence in neutral-red broth at 37° C. in twenty-four to thirty-six hours.

4. Give acid and gas in MacConkey's fluid.

5. Make phenol broth (·05 per cent.) turbid in twenty-four hours, with copious gas formation. Temperature, 37° C.

6. Produce indol in nutrient broth at 37° C. in three to five days.

7. Produce acid and gas in lactose-peptone-litmus broth in twenty-four to thirty-six hours.

8. Produce acid in litmus milk at 37° C. within twenty-four hours, and clot the milk in one to three days.

9. The flagellate bacillus is not stained by Gram.

Klein remarks on the necessity of distinguishing the true Bacillus coli from so-called coli-like microbes, and quotes an instance in which out of fifty-eight coli-like growths, only twelve were found to be the B. coli communis.

There can be no doubt that where these tests are applied, and no bacillus regarded as the B. coli communis which does not respond to every one, very few shell-fish from clean sources are found to contain this organism; hence if any considerable percentage show the presence of this bacillus there is strong presumptive evidence of their being derived from a polluted source.

In four instances Klein has found the B. typhosus in shell-fish. The method adopted appears to be the same as for the B. coli, using the Drigalski plate. On this medium the typhoid colonies may be recognized as isolated, translucent, blue dots in twenty-four hours, and in seventy-two hours the colonies are several millimetres in width. The colonies have: (1) a conical shape; (2) a prominent centre; (3) a flat thin margin, violet when viewed in reflected light on black ground; (4) have a violet blue centre, and a finely granular, and moist or glistening aspect. The individual bacilli are short, cylindrical in shape (not filamentous and not in chains), motile, and quickly clumping with typhoid serum. Subcultures should also be made on gelatine, in litmus-milk, and in MacConkey's solution and in broth.

The B. enteritidis of Gärtner may also be detected if present in the growth on the Drigalski medium. According to

Klein, it forms blue-violet colonies growing more slowly than those of the B. typhosus. The bacillus when examined is found to be shorter than the B. typhosus, it causes fluorescence in neutral red broth, turns litmus milk at first slightly acid, but after two or three days slightly alkaline, and it produces acid and gas in MacConkey's fluid. It does not agglutinate with typhoid serum in anything like the high dilution that B. typhosus does, and it is highly virulent to rodents after subcutaneous injection.

Care must be taken to apply all the confirmatory tests to the growth on the Drigalski medium, as other organisms occur in sewage which in their growth bear a more or less close resemblance to those produced by the three specific organisms, but which can be differentiated by the subsequent tests.

The bacillus of Gärtner should always be sought for in cases of poisoning, whether due to shell-fish or any other article of food, especially where diarrhœa is a prominent symptom.

CHAPTER XXII

UNSOUND FOOD (*continued*). MILK AND DAIRY PRODUCE

Dairy products which have caused disease have usually presented no abnormal appearance to the consumer. Very rarely can unsoundness be detected by mere inspection; hence seizures under the 'unsound food' sections of the Public Health Acts are rarely made. Milk especially is frequently so contaminated as to cause disease, although to all appearance good and wholesome. Such milk was obviously unsound and unwholesome at the time of sale, although its dangerous character could not be detected by inspection. The chief specific diseases which have been ascribed to milk are tuberculosis, scarlet fever, diphtheria, epidemic dermatitis, enteric fever, and cholera. A large proportion of the cases of 'summer diarrhœa' (zymotic enteritis) among children is probably due to milk, and from time to time outbreaks of illness characterized chiefly by sore throat and general depression have been traced to this food. Thrush is also probably occasioned sometimes by impure milk containing Oidium albicans, and foot-and-mouth disease, or at all events a septic condition of the mouth and throat, may also be similarly conveyed.

The identity of the bacilli of human and bovine tuberculosis was considered in connection with meat, and the importance of establishing the true relationship is indicated by the fact that a very considerable proportion, probably 20 per cent. or more, of milch cows in England have sufficient deposits of tubercle within their bodies to react to tuberculin. Fortunately the bacilli apparently reach the milk solely when the mammary glands are affected, and this is said to occur in only 3 to 4 per cent. of tubercular cows.

As, however, the milk sent out from a farm is mixed, a single cow with tuberculous udders is capable of inoculating a large amount of milk. Klein and Houston[1] found that out of ninety-eight samples from different farms, 7 per cent. contained virulent tubercle bacilli. In Liverpool in 1897, 2·8 per cent. of the milk produced within the city and 29·1 per cent. of that produced outside the city was tuberculous. In 1898 the figures were 8·3 and 17·8 per cent. respectively. Kanthack and Sladen found 56·3 per cent. of samples of milk from Cambridgeshire dairies to be tuberculous. In London dairies it is estimated that 25 per cent. of the cattle are suffering from tuberculosis, and Delépine finds that 25 per cent. of the samples of milk sold in Manchester are infected with tubercle. Similar figures have been given by Continental observers.

That tubercular diseases are caused by the consumption of infected milk few people will deny, although absolute proof is practically impossible. Assuming that Koch is correct in asserting that the bacilli of human and of bovine origin differ in certain respects, it does not follow that the bovine form is harmless to man. On the contrary, the followers of Koch admit that they have found the 'typus bovinus' in the glands of children suffering from primary intestinal tuberculosis. Dr. Nathan Raw,[2] who has had exceptional opportunities for studying tuberculosis in children and adults, adopts Koch's view that there are two distinct varieties of tubercle, the 'typus humanus,' chiefly conveyed by infection from one person to another, and the 'typus bovinus,' chiefly received into the body by infected meat and milk; but he is of opinion that bovine bacilli are very virulent for children, and are accountable for tabes mesenterica and other forms of abdominal tubercle. He further expresses the view that the bovine variety is more virulent for children than the human type, and he bases his conclusions upon the study of nearly 401 cases of tabes mesenterica observed during the last twelve years.

[1] *Report of Medical Officer, Local Government Board*, 1900–1, p. 330.

[2] *British Medical Journal*, October 21, 1905, p. 1,018.

With the exception of two children of consumptive mothers he has not known a single case to occur in a child fed entirely on breast-milk; the whole of them (with the above two exceptions) were reared for some considerable time on cows' milk. He further points out that when pigs are fed on tuberculous milk they develop 'scrofula,' and he has repeatedly seen children, and in some cases adults, suffering from enlarged neck glands, who had been consuming milk from cows suffering from tubercular disease of the udder. Out of 123 cases of meningitis in children under four years of age, he found that all without exception had been fed on cows' milk.

His experience in Liverpool, where much attention has been paid to the subject of tubercular milk, is most interesting. He has 'noticed a diminution in abdominal tuberculosis and enlarged glands during the last two or three years, due in a great measure to the rigorous inspection of all dairies,' and the supply by the city of sterilized milk for the poor. As the result of his extended experience and careful investigations he has arrived at the conclusion that, when tubercle is stamped out from cattle, surgical tuberculosis in children will to a great extent disappear with it.

The majority of the members of the medical profession who have given attention to this subject are agreed that there is some connection between tuberculosis in milch cows and tuberculosis in children. It is exceedingly significant that the death-rate from abdominal tuberculosis amongst children, taking the country as a whole, and tuberculosis amongst dairy cattle show no sign of decrease, if they are not actually increasing. In many of our largest towns the milk supplies are from time to time examined for the presence of tubercle bacilli, and when evidence of their presence is obtained the milk is traced to its source and the cows examined. Almost invariably an infected animal is found. This is eliminated from the herd, but there is reason to fear that such cattle are not always destroyed, but are sold to the owner of other dairy farms.

Milk outbreaks of scarlet fever and diphtheria are by no means uncommon. Nearly every year such outbreaks are recorded, some of them of a very extensive character. The infection is nearly always, if not invariably, derived from a human source, and the possibility of cows being susceptible to either of these diseases has never been satisfactorily established. The classical Hendon outbreak of 1885 was considered by Klein and others to be due to bovine scarlet fever, but Sir George Brown, the head of the Agricultural Department, held that the disease from which the cows suffered was cow-pox, and that the scarlet fever was derived from human sources.

Similarly it is extremely doubtful if cows suffer from a disease capable of transmitting diphtheria through their milk. In 1891 Sir Richard Thorne Thorne, in reviewing the chief epidemics of milk diphtheria, referred to the almost invariable association of such epidemics with lesions of the udders of the cows in the affected dairy, and Klein made some inoculation experiments which appeared to indicate that cattle were susceptible to the diphtheria bacillus, and that the illness was usually accompanied by an eruption on the udders from which the diphtheria bacilli could be recovered; but his experiments have been repeated with contrary results by Loeffler and Abbott. Dean and Todd[1] investigated a small outbreak of diphtheria directly connected with the milk from two cows. Both the cows were suffering from papules and ulcers on the udders and teats, and virulent diphtheria bacilli were isolated both from the lesions and from the milk. The eruption was of a contagious nature, and was experimentally communicated to the teats and udder of a healthy cow, but no diphtheria bacilli were to be found in the lesions so produced. Similarly the crusts were inoculated on the abdominal skin of two calves, one of which had previously received 10,000 units of diphtheria antitoxin; in both cases ulcers resulted, but in neither case

[1] *Journal of Hygiene*, vol. ii. p. 194.

could diphtheria bacilli be isolated from the lesions. The investigators came to the conclusion that the cows, whose milk was associated with the diphtheria outbreak, were not themselves suffering from diphtheria, but that the lesions on the teats and udders were of a non-diphtheritic character, and that the specific organisms had probably been introduced by the hands of milkers, and had multiplied in the ulcers.

The typhoid bacillus may be introduced into milk in several ways, probably the commonest being through water, used either for washing the utensils or for diluting the milk. The Clifton outbreak in 1897[1] is an example of the former, and the Moseley outbreak in 1873[2] of the latter. Similarly a milk-borne epidemic of typhoid fever occurred in Springfield, Mass., and was due to the milk cans being immersed in a polluted well to cool.[3] Personal contact was probably the means of introducing infection in the Penrith epidemic of 1857,[4] the mother of a girl suffering from a mild attack of typhoid fever both acting as nurse and taking part in the milking. Contaminated cloths used for wiping the utensils appeared to be responsible for an epidemic in Barrowford, Lancs., in 1876, whilst to the introduction of particulate infective material from dried excreta in a defective drain was ascribed an outbreak at Millbrook in Cornwall (1880).[5] A small outbreak in Leeds during the spring of 1900 appeared to be due to the infection of the milk during the emptying of a privy at a farm, the primary attacks suddenly occurring within a few days of each other and as suddenly ceasing. The privy under suspicion had been emptied about a fortnight before the first case of typhoid fever began.

The possibility that flies may convey infection from a privy, or from fields fertilized with human excreta, &c., should also not be lost sight of.

[1] *Trans. Epidem. Society*, vol. xvii.

[2] *Local Government Board Report*, 1874.

[3] *Boston Medical and Surgical Journal*, 1893, ii. p. 485.

[4] *Edinburgh Medical Journal*, 1858.

[5] *British Medical Journal*, vol. i., 1881.

In an epidemic described in the 'British Medical Journal,' 1880, vol. i. p. 89, is raised the suspicion that cows may themselves suffer from an invasion of the typhoid bacilli, and be capable of transmitting the infection to man through their milk; if this be the case it is probable that the bacilli reach the milk from the alvine discharges. The possibility of this happening is emphasized by an epidemic at Eagley and Bolton in 1876, investigated by Power.[1]

Cholera has also been spread by means of milk through the use of polluted water, but inasmuch as the comma bacillus does not thrive in an acid medium, milk is not so favourable a culture fluid as it is for other pathogenic germs. In this connection reference may be made to Klein's investigations on the behaviour of certain bacilli in milk.[2] Tubercle bacilli were found to flourish in milk at 37° C., and in some instances even to increase in virulency. The bacilli also grew in sterilized cream and upon sterilized cheese. The typhoid bacillus multiplied in milk at 20° and at 37° C., and in cream at 20° C. Cheese was apparently unfavourable. Diphtheria bacilli grew in milk at 20°, but not at 37° C., whilst cream and cheese appeared to be unsuitable media. The Streptococcus conglomeratus flourished in milk at both temperatures, and to a limited extent in cream and on cheese at 20° C., but not at 37° C.

The germ or germs actually responsible for zymotic enteritis has been the subject of considerable speculation and investigation. Delépine,[3] after discussing the literature and bacteriology in connection therewith, gives good reasons for believing that the majority of cases of milk-borne diarrhœa are due to infection by the B. enteritidis (Gärtner) or other species of the 'colon group.' He holds that the infection takes place at the farm, though this is disputed by Newsholme and others. On the occasion of a milk-borne epidemic of diarrhœa in Manchester

[1] Hamer, *Manual of Hygiene*, p. 198.
[2] *Local Government Board Report*, 1899–1900.
[3] *Journal of Hygiene*, iii., 68.

(1894), affecting at least 180 families, Delépine isolated a bacillus of the Gärtner group from a sample of the implicated milk, which bacillus was pathogenic for guinea-pigs, and caused peritonitis, intense hyperæmia of the small intestines, and congestion of the lungs.

Outbreaks of sore throat due to milk have been reported by many observers. In 1875 an epidemic occurred in South Kensington, and was investigated by Sir R. Buchanan.[1] In 1881 a similar outbreak at Rugby School was apparently due to the milk of a cow suffering from mastitis.[2] In 1899 Dr. J. King Warry reported on an epidemic conveyed by milk,[3] the illness being characterized by sore throat of a septic character. An outbreak of illness not entirely distinguishable from scarlet fever occurred at Brighton in 1900, and was attributed to milk that had apparently been infected from human sources.[4] Dr. Pierce, Medical Officer of Health for Guildford and Woking, traced an extensive epidemic occurring in his districts in 1903 to milk from a special farm. The chief symptoms recorded were an affection of the throat, either quinsy, follicular tonsillitis, or ulcerated sore throat; great constitutional disturbance; and in some instances abscesses in connection with the lymph glands, and facial erysipelas, whilst in one patient a fatal attack of ulcerative colitis occurred. The chief organisms present in the throats examined were streptococci and staphylococci. Out of twenty cows examined at the farm four gave impure milk, and from two of them the liquid consisted largely of pus. From the pus, cocci, similar to those present in the throats of the patients, were isolated. Possibly, if the milk had been seen before it was mixed and delivered, it might have furnished one of the rare instances in which milk could be seized under the Public Health Act.

An outbreak of disease mainly characterized by sore throat

[1] *Local Government Board Report*, 1876.
[2] *British Medical Journal*, 1881, vols. i. and ii.
[3] *Annual Report, Borough of Hackney*, 1900.
[4] Newsholme, *Journal of Hygiene*, vol. ii. p. 150.

occurred in Colchester during the month of April 1905, and was investigated by Dr. Savage, the Medical Officer of Health. It commenced on the 17th and ended on the 29th, and it is believed that between 500 and 600 people were attacked. It was confined to a limited area, the best part of the town, and to the users of milk from a particular farm. Of the twenty cows kept at this farm nineteen were healthy, but the twentieth had a diseased udder, and the milk drawn from one quarter was quite brown and consisted of dilute pus. Pus and the organisms associated therewith were found in the implicated milk.

In 1904 an equally extensive epidemic occurred in Finchley and the neighbourhood, upwards of 500 persons being affected. Dr. Kenwood considered that the milk was infected through two cows that had suffered from indefinite symptoms.[1]

A milk-borne epidemic of somewhat doubtful character occurred in Lincoln in 1902, and was investigated by Dr. Darra Mair.[2] Some 200 persons were affected, and in many cases the medical attendants regarded the illness as scarlet fever, though the bacteriological examination of the throats did not bear out this view. It was suggested that the illness may have been due to a fungus of the nature of 'rust' which had affected the field frequented by the implicated cows. In America 'tyrotoxicon' has been found in milk which had given rise to poisonous symptoms in those consuming it, but no similar cases appear to have been recorded in this country.

Several outbreaks of epidemic skin disease have been reported by the Medical Officers of the Local Government Board as having occurred in workhouse infirmaries. Most of these were attributed to the milk supplied, and in the most recent outbreak, referred to in a previous chapter, the implicated milk was found to contain formalin. It is also suggested that this chemical may have been the actual cause of the disease. Unfortunately in the previous outbreaks this preservative was not sought for. This particular form of skin disease was first

[1] *British Medical Journal*, 1904, i. 602.
[2] *Local Government Board Report*, 1902–3.

described in this country in 1891 by Dr. Savill, then Medical Superintendent of the Paddington Infirmary, in which 163 cases occurred. In 1893 an outbreak (eighty-six cases) occurred at the Bethnal Green Workhouse Infirmary, and similar outbreaks of lesser magnitude in other infirmaries. The disease bears some likeness to pityriasis rubra and to acute general eczema, and the presence or absence of certain characters gives rise to two more or less distinct types, the 'dry' and the 'moist.' The fatality ranged from 5 to 12 per cent. of the attacks. The evidence[1] with regard to the milk bearing some causal relationship to the disease was in most cases conclusive. In several instances the outbreaks occurred in different infirmaries which were being supplied with milk by the same contractor, and this milk was of a decidedly inferior character.

The food upon which cows are kept rarely, if ever, affects the appearance of the milk, but on occasions has affected the taste, and when such milk has caused gastric disturbance this has been attributed to the food supplied to the cows. This is possibly erroneous, but if true it is only an additional reason for giving careful attention to the character of the food. Where cows have eaten of the leaves of the sumach (*Rhus toxicodendron*)—often found in shrubberies—it is alleged that the milk has been affected, and has caused disturbance of the digestive system of those who consumed it.

From time to time milk becomes infected with organisms which affect its appearance, but such milk is never offered for sale; if offered it should certainly be seized as unsound. The Bacillus cyanogenes causes milk to become blue, the Bacillus synxanthus imparts a yellow tint, the Bacillus prodigiosus, the B. lactis erythrogenes, Sarcina rosea, and possibly other organisms, produce a red colour, whilst the Bacillus lactis viscosus and the Bacillus actinobacter are said to be the cause of the ropy character often found when cows are suffering from 'garget,' but sometimes occurring in warm weather in the milk from apparently healthy cows. It is doubtful, however, whether

[1] *Report of the Medical Officer of the Local Government Board*, 1893–4, p. xix.

any of the above-mentioned organisms possess pathogenic properties. Milk absorbs odorous substances with wonderful avidity. A short time ago one of us had occasion to investigate the cause of a disagreeable odour of the milk supplied by a certain dealer. It was found that the milkman had a wound in his hand which was covered with an iodoform dressing. When another person milked the cows the milk had no longer an objectionable odour.

Milk occasionally acquires a bitter taste which affects the cream and butter made therefrom. This is no doubt due to some organism not yet recognized. Some time ago one of us had to advise a cow-keeper and dairyman as his milk was persistently bitter, if kept, and the cream and butter made therefrom had a similar taste. The dairy and cowsheds were thoroughly cleansed, hot-limewashed, and all the utensils disinfected with formalin. There have been no complaints since. The milk did not apparently produce any ill effects on the consumers. Very rarely milk has been observed to be 'soapy,' having the taste of soap, and frothing much on agitation. The cause of this change is unknown, but it is probably due to the action of bacteria. The souring of milk from the production of lactic and butyric acids is a change so well known as not to require more than mention.

Condensed milk is not unfrequently found to be unsound, and in consequence seized and condemned. Usually the only evidence of unsoundness is the generation of gas within the tins, and the consequent bulging of the ends. There are apparently no records of such milk being used and causing any injury to health. It is often, after seizure, allowed to be sold for pig feeding, and when so used we have been unable to hear of any ill effects following. A sample of such a batch of tins was recently examined by one of us. The tins were 'blown.' The milk was normal in appearance and odour, but the taste was suggestive of something abnormal. Young pigs ate it with avidity, and certainly were not affected by it. It is a well-known fact that certain bakers purchase such condensed

milk, and use it in making bread and pastry. No case of illness has come to our knowledge which has been attributed to this practice. Notwithstanding this, milk which is obviously undergoing decomposition with the evolution of gas cannot be considered fit for the food of human beings, and should be regarded as unsound.

Milk has usually been looked upon as a food which could not be dealt with by seizure under the sections relating to unsound food, but obviously cases occur in which the milk may be so seized and taken before a magistrate for condemnation. The first, and as yet the only, recorded case occurred in St. Pancras in April 1905, and is of sufficient novelty and importance to warrant us in including an account of it, since it gives in detail the reasons assigned for seizing the milk, and the subsequent examination made to confirm the opinion that it was so polluted as to be unfit for human consumption.

It is very probable that, if churns of milk were occasionally 'strained' by the inspector, sufficient evidence of the presence of filth would be found to justify seizure. A few prosecutions of this kind would tend to make the dairy farmer much more careful in the process of milking, and to insist upon greater cleanliness of his cows, and of his milkers.

'Dirty and Contaminated Milk dealt with as Unsound Food.[1]—At Marylebone Police Court, on April 14, John Roberts, a farmer in Northamptonshire, appeared in answer to two summonses, taken out by the St. Pancras Borough Council, charging him, as owner of a churn of milk sold to the Dairy Supply Company (Limited), which was unwholesome and unfit for food, with depositing the milk at Euston Station for sale. Mr. Clarke Hall, barrister, prosecuted, and Mr. Freke Palmer, solicitor, defended. Mr. Clarke Hall said that the proceedings were taken under section 47 of the Public Health (London) Act, 1891. This was the first case of the kind in regard to milk. The defendant had been

[1] *Public Health*, June 1905.

under contract with the Dairy Supply Company since March 25, 1904, to supply them with pure new milk. On February 20 the churn of milk was sent to London, and was seen at Euston Station by a sanitary inspector in the employ of the Council, who found on the top, dirt, consisting of cow dung, straw, and hair. Dr. Sykes, the Medical Officer of Health, pronounced the milk unfit for food. It was brought to that Court, and Mr. Paul Taylor condemned it. Three samples, two from the top and one from the bottom, were submitted for analysis to Dr. Eyre, bacteriologist at Guy's Hospital. The result showed the presence of a brownish deposit amounting to at least 4 per cent. in the samples taken from the top, and 8 per cent. in the sample from the bottom, consisting almost entirely of fæcal matter and pus cells. Experiments were made with this stuff on a healthy guinea-pig, and it was shown that the offensive matter contained tubercle bacilli, the post-mortem examination of the animal showing clearly that it was affected with tuberculosis. He submitted that it was milk of this kind that was responsible for the large mortality among children, and as it was a real danger to the public health the Council had determined to take action. Evidence was then called in support of the statement. For the defence, Mr. Freke Palmer said that the difficulty he had to contend with was that, unlike cases under the Food and Drugs Act, defendant was not made aware that the samples had been taken until some time afterwards, and was therefore unable to make any inquiries as to how the milk came to be in the state in which it was found. The milk was sent off in a clean, pure, and wholesome condition, and he suggested that the presence of the filth in it on its arrival was due to the carelessness, spite, or the interference of some one while it was in transit. He submitted that the Public Health Act did not apply to such a case as this. The defendant was called, and stated that all his cows were in a healthy condition, and this was supported by a local sanitary inspector and a veterinary surgeon. Mr. Chapman adjourned the case to the

Tower Bridge Police Court, where the hearing was continued on May 12. John Elliott, employed by the defendant to milk the cows, gave evidence for the defence as to the straining of the milk, and the care taken to prevent any impurities from getting into it. In reply, several railway officials were called to prove that the milk had not been tampered with on the railway. Charles Gill, station-master at Castle Ashby, said that on several occasions he had seen filth on the defendant's milk. Mr. Chapman came to the conclusion that the filth on the milk came from the defendant's farm. The defendant shared his responsibility with others, but the law made him responsible for the acts of his servants. The defendant was fined 25*l.* and five guineas costs.'

The milk from cows suffering from disease is frequently quite normal in appearance, but it may show some abnormality when submitted to careful chemical analysis. Frequently the proportion of salts is increased, or the presence of cholesterin may be detected, but no such tests afford any indication of the wholesomeness or otherwise of the milk. Where a cow is suffering from foot-and-mouth disease, pleuro-pneumonia, cattle plague, or tuberculosis of the udder it is illegal to supply the milk for human consumption, but it may be used for feeding pigs after being boiled. Milk from cows suffering from foot-and-mouth disease has on occasions proved fatal to calves and pigs, but possibly in such cases the milk had not been boiled. Unsound milk is most readily detected by microscopic examination, search being made for pus cells, blood corpuscles, and certain specific organisms. Pus cells are said to be frequently met with in milk, but this is contrary to the experience of the authors (*vide* Chap. XVIII.). Eastes found them in 30 per cent. of the samples of milk examined, whilst Stokes and Wegefarth, in Baltimore, apparently found them in all milks, even from cows which had been submitted to careful veterinary examination and pronounced quite healthy.[1] An inflammatory condition of the teats and udder of the cow ('garget') is very

[1] *Journal of State Medicine*, vol. v. p. 489.

common, and sometimes appears to be epidemic. The attack may be so mild as to escape observation, and pus cells be abundant in the milk. Stokes and Wegefarth refer to several outbreaks of disease (chiefly a form of gastro-enteritis) apparently attributable to the use of milk from cows with inflamed udders, and there can be no doubt that milk containing pus is not adapted for human consumption. Although they would not condemn a milk because it contained a few pus cells, they suggest that where 'the microscopical examination of the centrifugalized sediment of the milk from a herd of cows contains an excessive amount of pus' a careful inspection of the herd should be made. It is noteworthy, however, that these observers found far fewer pus cells in the milk from well-fed and well-housed cows than in that from cows kept under insanitary conditions. It is a grave question, however, whether any milk containing purulent matter should be permitted to be sold.

Unfortunately every sample of milk examined is found to contain traces of filth, almost innumerable bacteria, staphylococci, and bacilli, with a few streptococci, spores of moulds, epithelial scales, and small cells easily confounded with pus cells, but staining differently with Ehrlich's triacid stain. If a cow is suffering from mastitis, pus cells will be very abundant, and be associated with streptococci. Leucocytes and occasionally blood corpuscles may be found in milk from apparently healthy cows. It is only, therefore, when these cells, &c., are found in excessive amount that objection can be taken to the milk. Milk which has undergone a change making it 'ropy,' discoloured, or imparting to it an odour, is certainly unfit for human consumption, and milk which contains particles of hair, straw, hay, fæcal matter, and pus corpuscles should be condemned, especially if pyogenic organisms can also be detected. Most of these constituents, if present in dangerous amount, can be isolated for microscopical examination in a few minutes by means of a centrifuge. If suspected milks were promptly dealt with they could in many cases be examined and seized before reaching the

consumer, and now that an example has been set by the St. Pancras Borough Council we may hope that other authorities will take similar action. A few prosecutions of this kind would probably effect a greater change for the better than all the bylaws which can be devised.

Cream, as distinguished from milk, has not often been held responsible for cases of illness, though no doubt it is frequently capable of causing toxic symptoms. An outbreak of typhoid fever occurring among some guests at a certain dinner party held in South Kensington in 1875 was, however, ascribed to this article.[1]

Ice-creams have frequently given rise to gastro-intestinal disturbance among the consumers; not only are they likely to contain such organisms and their products as may have been present in the original milk (though as a rule some degree of pasteurization or sterilization is adopted in their manufacture), but during their preparation and storage they are liable to be exposed to the most gross pollution at the hands of the street retailers, whose premises are frequently totally unsuited for the purpose. Dr. George Turner has described an epidemic of typhoid fever, occurring at Deptford in 1891, which was apparently caused by ice-cream, and several other outbreaks have since occurred attributable to the same cause. Bacteriological examinations frequently show that the ice-creams as sold by itinerant vendors swarm with bacteria, and are quite unfit for food.

The following brief account of an outbreak of poisoning due to ice-creams is typical of many others recorded. It occurred in Birmingham during the summer of 1905, and was investigated by Dr. Robertson, the City Medical Officer of Health. Out of 250 consumers served, fifty-two cases of illness occurred, four only of the patients being over fourteen years of age. The interval which elapsed between the eating of the ice-cream and the onset of the illness varied from half an hour

[1] Paper by Ernest Hart on Typhoid Fever, 1881.

to eight and a half hours. All the persons suffered from diarrhœa and collapse. No irritant poison was discoverable by chemical analysis. Professor Leith examined the ice-cream bacteriologically and found therein a bacillus of the colon group, capable of causing the death of guinea-pigs. From an examination of the premises in which the ice-cream was manufactured, it appeared probable that it had become contaminated whilst standing in the cooling shed after boiling and before freezing. Opposite this shed there were three water-closets in an extremely filthy condition, and possibly organisms of excremental origin had fallen upon one of the buckets of the cream while it was in a warm condition. These would rapidly multiply, and may have produced toxins or ptomaines. Neither the bacilli nor their poisonous products would be affected by the subsequent freezing.

In London, and in several provincial towns, it is made illegal for an ice-cream maker or dealer to make, sell, or store ice-cream in any room used as a living or sleeping room, or to expose the ice-cream to any source of infection or contamination. Every itinerant vendor must exhibit on his barrow his name and address, or the name and address of the person from whom he obtains the ice-cream. This has been followed by the registration of all ice-cream makers and the frequent examination of their premises, and great improvements have been as a consequence effected.

Butter, being produced by fermentative changes, is presumably liable to contain many substances, which may be prejudicial to health, derived from the life-processes of the extensive bacterial flora usually present in cream, though, when the butter is made on scientific lines from pasteurized cream, there is little risk of such deleterious organic substances being present. Instances of poisoning are, however, uncommon or seldom reported. Accounts of two small outbreaks of disease apparently due to rancid butter are to be found in the 'Journal of State Medicine' (vol. iv. p. 512). In both instances 'ptomaines' were isolated from the suspected samples. Tyro-

toxicon, to which reference will be made when cheese is under consideration, may occur also in butter and in milk.

Klein examined twelve samples of butter bacteriologically, by making an emulsion and injecting portions into guinea-pigs; two out of twenty-one of the animals developed localized abscesses, from which Staphylococcus pyogenes aureus was recovered.

Butter is rarely if ever seized as being 'unsound.' If kept until rancid, it would certainly be unwholesome and seizure be justifiable, but the condition would be so obvious that no dealer would think of exposing it for sale, though he might dispose of it to an unscrupulous pastry-cook, the class of person who would purchase 'blown' tins of condensed milk.

Cheese.—The most important illness associated with the consumption of cheese is that due to the presence of tyrotoxicon. This poison, formed by certain bacteria from nitrogenous substances, was first investigated by Professor V. C. Vaughan in connection with extensive outbreaks, involving some 300 persons, in Michigan, U.S.A., during the years 1883 and 1884.[1] It appears to be an unstable substance, readily destroyed by heat, and is a virulent poison for many animals as well as man. The symptoms are mainly vomiting, diarrhœa, and collapse.

Dr. Newman,[2] Medical Officer of Health for Finsbury, reported on an outbreak of this nature occurring in 1901. Seventeen persons were affected, the symptoms appearing in from two to eight hours after the cheese was eaten. Epigastric pain, rigors, vomiting, diarrhœa, prostration, and some fever formed the leading features of the illness. Convalescence commenced in about forty-eight hours. Mr. Colwell examined samples of the cheese (Dutch cheese) and detected the presence of tyrotoxicon.

A similar epidemic, involving twenty-seven men with three fatal cases, happened at Aldershot in 1899,[3] among two field columns. The symptoms noticed were fever, the temperature

[1] Newman's *Bacteriology and the Public Health*, p. 251.
[2] *Ibid.* [3] *Journal of State Medicine*, vol. viii. p. 60.

ranging from 100° to 103° F., vomiting, hæmatemesis, failing pulse, cramps, and in some instances jaundice. Autopsies in the fatal cases revealed inflammation of the stomach with submucous hæmorrhages and œdema, and similar but less severe inflammation of the duodenum and jejunum. Eight sheep fed on remnants of the cheese sickened, and six of them died, similar post-mortem appearances being present. Portions of the cheese from the sheeps' stomachs were examined by Luff, and tyrotoxicon was found. Bacteriological examinations were made, but gave no clue as to the nature of the illness.

Vaughan found a toxalbumin in some cheese which had caused the illness of those who had partaken of it. Tyrotoxicon was not detected in this sample.

Mann says that 'old, decayed cheese yields an alkaline reaction, and has frequently given rise to colic, diarrhœa, dizziness, diplopia, precordial pain and collapse.' Doubtless in these cases some bacteria had gained access capable of producing a 'toxin' or a ptomaine with poisonous properties, and Vaughan thinks this form of poisoning is more frequent than that from tyrotoxicon.

Eggs.—It is probable that even eggs may at times contain micro-organisms capable of causing illness. In the 'Lancet,' 1905, vol. i. p. 464, is an account of an epidemic of food poisoning occurring in Paris, investigated by MM. Metchnikoff and Girard, the implicated food being 'cream cakes.' The 'cream' is made by slightly warming the white of eggs and adding a mixture of gelatin, sugar, and milk at a temperature of 80° C. This mixture should prove an excellent medium for the propagation of bacteria and their toxins, and M. Metchnikoff considered that the bacteria were derived from the eggs, which, he asserts, occasionally contain micro-organisms when laid.

CHAPTER XXIII

EXAMINATION OF MILK AND OTHER DAIRY PRODUCE

Milk. Examination for Dirt.—If the sample contains any visible particulate matter, its character may possibly be recognized by the aid of a hand lens. If not it can be mounted in water or dilute glycerine, and examined under the microscope. Particles of hair, straw, hay, &c., may thus be recognized (Plate V.).

The quantity of dirt present can be determined by using a litre of the milk, taken after thorough agitation, placing it in a long cylinder and allowing it to stand for three or four hours. The supernatant milk is then syphoned off, leaving about 25 c.c. at the bottom of the cylinder. To this about half a litre of filtered water is added and the mixture again allowed to stand for a few hours. This process is repeated until the water remains clear, when the deposit is transferred to a tared filter, dried and weighed.

A really clean milk will not yield more than 3 to 5 mlgms. of dry residue; ordinary samples may yield from 10 mlgms. or even more, according to the degree of foulness.

If this test yields much more than 10 mlgms. of dry residue, and the microscopic examination of the residue obtained by aid of the centrifugal machine shows that it is of an objectionable character, the milk may fairly be considered unsound and unfit for human consumption.

In all cases, however, whether there are visible particles or not, 10 c.c. or more of the milk taken after agitation should be placed in a pointed tube, and submitted to centrifugalization for a few minutes. The cream will then come to the top and the particulate matter be deposited in the narrow end

of the tube. Pipette carefully off the cream and reserve for further examination, and afterwards as much of the liquid as can be removed without disturbing the deposit; fill up the tube with distilled water and again treat in the centrifuge. The sediment then can be examined, its amount being approximately noted. In a clean good milk the quantity should be inappreciable. Spread the sediment evenly over the surface of one or more glass slides, and allow to dry at a very gentle heat without access of dust. Pass, in the usual manner, three times through the flame of a Bunsen burner in order to fix the film, and remove the fat by immersing for a few minutes, first in absolute alcohol, then in ether. When the excess of ether has evaporated the film may be stained with Loeffler's blue, or with Ehrlich's triacid stain, or by Gram's method, or by the Ziehl-Neelsen method, or different slides may be differently treated. The Ziehl-Neelsen method must be used if tubercle bacilli are being sought for.

The preparations can now be examined, first with a $\frac{1}{6}$-inch objective and afterwards by aid of the $\frac{1}{12}$-inch oil-immersion lens.

Examination for Pus Cells.—Pus corpuscles may be found, and are of the greatest significance if abundant, and if blood cells and streptococci are also present the milk must be considered actually dangerous to health. The presence of blood corpuscles alone, if in any number, should suffice to condemn the milk as unwholesome.

Stokes and Wegefarth,[1] as the result of their investigations on the presence of pus cells in milk, suggest a standard for the exclusion of cows from a herd. They say, 'The standard for exclusion must of necessity be arbitrary, but following the method . . . described, an average of more than five pus cells to the field of the oil-immersion lens should exclude an animal from the herd.' It does not follow that they would approve of the use of milk from a herd in which anything like the above number of pus cells could be found. On the contrary,

[1] *Journal of State Medicine*, vol. v. p. 439.

they would regard with suspicion any milk in which pus cells were easily found, and suggest an immediate examination of the herd. The process adopted by them and referred to above is thus described: 'The milk (10 c.c.) is first centrifugalized two and a half minutes by means of the Lentz centrifuge. The supernatant fluid is then poured off, and the sediment is spread evenly over the surface of an ordinary glass slide. The specimen is then dried over the flame of a Bunsen burner or in a water-oven. Ether is then applied until all superfluous fat is removed, and the slide is stained with Loeffler's methylene blue. The examinations are made with a one-twelfth inch oil-immersion lens.' The question arises, however, as to what is a pus cell? Leucocytes are found in all milks, and these Stokes and Wegefarth, and possibly others, seem to regard as pus cells. Leucocytes undergoing degenerative change and showing two or more distinct nuclei when treated with Ehrlich's triacid stain, or when stained with eosin and methylene blue, may be regarded as pus cells, and as indicating the presence of purulent matter. When present these will be found in the centrifugalized deposit associated with streptococci, and often also with red blood corpuscles.

Examination for Streptococci.—If not found during the examination of the deposit, a little of this may be diffused through 1 or 2 c.c. of normal saline solution, and brushed over the surface of agar plates. Incubate at 37° C., and examine with a lens the colonies as they appear, and pick out those which resemble streptococci. When found, the character of the particular organism isolated may be worked out if deemed desirable.[1] A portion of the culture injected into the groin of a guinea-pig will set up active inflammation with the formation of pus, in which the streptococci will abound.

Examination for Tubercle Bacilli.—The Ziehl-Neelsen stain may reveal the presence of bacilli resembling those of

[1] *Vide* Gordon on the 'Differentiation of Streptococci,' *Lancet*, Nov. 11, 1905, p. 1,400.

tubercle in the deposit, but they are much more likely to be found in the cream. The result, however, is of little value, since the presence of tubercle bacilli can only be affirmed after an experiment on guinea-pigs. The deposit obtained from 100 c.c. or more of the milk by aid of the centrifuge should be injected into the subcutaneous tissue of the groin of the animal and the effects noted. The rapidity of infection will depend upon the virulency of the milk. The inguinal and popliteal glands may show signs of enlargement in ten days, or not even until the end of a month. When killed, these glands and the spleen are examined for the detection of the specific bacilli.

Examination for Diphtheria Bacilli.—The diphtheria bacillus has rarely, if ever, been isolated directly from milk. If present, its detection may be attempted by injecting the deposit from 10 to 50 c.c. of the milk into the subcutaneous tissue of a guinea-pig, and examining the fluid from the consequent œdematous tissue. Portions of this fluid must be used for inoculating several tubes of blood serum, and the growths examined in the usual way.

Examination for Organisms of Intestinal Origin.—If milk is contaminated with an appreciable trace of fæcal matter, there should be no difficulty in detecting both the Bacillus coli communis and the Bacillus enteritidis sporogenes. The former is occasionally found when the latter cannot be detected, in which case the organism may not actually have been introduced with a mass of fæcal matter, but with dust from the byre.

To detect the Bacillus coli, dilute 1 c.c. of the milk with 9 c.c. of sterile water, and make a further dilution with 1 c.c. of the mixture and 9 c.c. of sterile water. To a tube of bile-salt-lactose-litmus broth add 1 c.c. of undiluted milk, to a second 1 c.c. of the first dilution, and to a third 1 c.c. of the second dilution. Place in the incubator at 37° C. (preferably 42° C.) for twenty-four hours, and if fermentation takes place proceed as described on p. 252. Should the Bacillus coli be found in the highest dilution, it is obvious that the milk contains more

than 100 per c.c., a number which would never be found in a clean milk.

The Bacillus enteritidis sporogenes may be detected and roughly estimated in the following manner. In a sterile tube place 10 c.c. of the milk to be examined, and into two tubes, each containing 10 c.c. of sterilized and recently boiled and cooled milk, add respectively 1 c.c. of the milk and 1 c.c. of a 1 in 10 dilution. Place all the tubes in a water-bath at 80° C., and pour over the surface of the milk in each sufficient sterile melted vaseline to form a column about half an inch in depth. At the end of fifteen minutes remove from the water-bath, cool, and place in the incubator at 37° C. for three or four days. In the presence of the Bacillus enteritidis sporogenes the milk will form a ragged clot, with a pink tint at the surface, the serum will be comparatively clear, and the vaseline plug will have been forced to the mouth of the tube by the gas generated. The liquid will have a strong odour of butyric acid, and the serum will be found to swarm with bacilli, not bearing spores. In a clean milk the spores of the Bacillus enteritidis sporogenes should not be found in 10 c.c.; the more polluted the milk, the smaller is the quantity in which they can be detected.

Oidium Lactis.—The oidium lactis may be found in sour milk, and is possibly identical with the oidium albicans. It is more probable, however, that they are distinct species, otherwise 'thrush,' which is due to the latter, would be far more common. A number of cases occurred some time ago in a small community, children and adults being affected, which one of us thought were possibly due to infected milk. If present, the hyphæ and spores would be detected by the microscope in the deposit from the milk (Plate V.). If very abundant, the milk should be regarded as unsound.

Enumeration of the Bacteria present.—To ascertain the number of bacteria capable of growing on gelatine present in a sample of milk a series of dilutions must be made with sterile water.

(*a.*) 1 c.c. of milk to 1 litre of water	. .	1 : 1,000
(*b.*) 1 c.c. of (*a*) to 9 of water	. . . .	1 : 10,000
(*c.*) 1 c.c. of (*b*) to 9 of water	. . . .	1 : 100,000
(*d.*) 1 c.c. of (*c*) to 9 of water	. . . .	1 : 1,000,000

One c.c. of each dilution is used for making a gelatine plate, and the colonies counted from day to day by aid of a pocket lens. The actual number should be taken from those plates which are not liquefied, and upon which the colonies are countable at the end of the fourth day. The results, when two or more plates are counted, are not always concordant, as some of the bacteria in the milk occur in minute masses which may or may not become diffused during the dilution. The average of the numbers may be taken, but, if the above supposition is correct, the highest count may most nearly approximate to the truth.

The substitution of boiled or pasteurized milk for fresh milk may be ascertained by the following tests:

1. To about 10 c.c. of the milk in a test-tube add a few drops of tincture of guaiacum; if the milk turns blue it has not been boiled. If no blue tint appears, the milk has possibly been heated to or nearly to the boiling point; but in our hands this test appears to be far from reliable. The following give much more satisfactory results:

2. To a similar quantity of the milk add a few drops of a 1 per cent. solution of hydroquinone (para-dioxybenzine), agitate and add, drop by drop, solution of hydrogen peroxide. A rose colouration develops in raw milk, but not in milk which has been heated to 80° C. or upwards.

3. To another test-tube containing the milk apply the same test as (2), substituting for the hydroquinone a 1 per cent. solution of ortho-methyl-aminophenol. Again raw milk becomes rapidly rose coloured, whilst milk which has been heated to 80° C. or upwards for a short time remains uncoloured. If the milk has been kept at 75° C. for half an hour it does not acquire a rose tint.

4. In this test metol is substituted for hydroquinone in

(2). Upon the addition of a drop or two of the 20 per cent. hydrogen peroxide solution unboiled milk rapidly assumes a dirty mauve colour, whilst boiled milk is not affected.

Milk has probably never been seized merely on account of its having become sour. When the lactic acid produced by the fermentation of the lactose reaches a certain stage the casein is curdled and the milk is unsaleable, but long before this stage is reached the milk is unfit for food, especially for infants. Probably the odour alone would be sufficient to decide when this stage had been reached, a milk with a decidedly sour odour being regarded as unsound. Milk containing 0·25 per cent. of free acid, estimated as lactic acid, will curdle when heated to 100° C., and 100 c.c. of such a milk would require 28 c.c. $\frac{n}{10}$ soda for neutralization. A milk, 100 c.c. of which requires 20 c.c. of $\frac{n}{10}$ soda to neutralize its acidity, is decidedly sour and more or less unwholesome. Phenol-phthalein is usually employed as the indicator in milk titration.

Condensed Milk.—Condensed milk is rarely seized as being unwholesome unless the tins containing it are 'blown.' It is usually assumed that this is due to the formation of gas by the decomposition of the milk by means of bacteria, but this is certainly not always the case, since in some cases the milk from such tins is found to be absolutely sterile, and in other cases in which the tins are not 'blown' the milk may not prove to be sterile. Dodge examined a number of blown tins containing sterile milk, and attributed the formation of the gas to electrolytic action between the metals of which the cans were composed and the acids generated by the growth of bacteria in the milk before the latter was condensed. It is a question, therefore, whether the presence of a small number of 'blown' tins justifies the condemnation of the whole batch of which they form a part.

Cream and Ice-Cream may be examined in the same way as milk, after dilution with two or three volumes of filtered water.

Butter may be examined by adding 1 gram to 50 c.c. of filtered water, warming to 35 or 40° C., and agitating until an

emulsion is formed. The mixture can then be centrifugalized and the deposit examined. Portions of the emulsion may also be taken for making gelatine plates, and for the detection of certain organisms. In selecting the samples of butter the outside of the piece should be avoided, a portion being taken from the interior.

Cheese must be judged by its physical characters, but it should be remembered that a condition which would condemn one variety may represent the state of perfection in another. Excessive mouldiness, associated with a fusty odour, and worms and mites penetrating the mass would justify seizure. The 'mite' so common in cheese is the Acarus domesticus, whilst the so-called 'worms' are the larvæ of a fly, the Piophila casei. On rare occasions cheese has caused ill effects, but when this has been the case there has usually been nothing in its appearance, odour, or flavour to warn the consumers; in some recorded instances, however, the taste was bitter or at least unnatural. A cheese with a bitter, rancid, or unnatural flavour should, therefore, be regarded with grave suspicion. If the odour is decidedly putrid the cheese must be unwholesome, but care must be taken not to confound putridity with the peculiar change some cheeses undergo in the process of ripening. This change, which renders certain kinds of cheese disgusting to some persons, causes others to regard them as being in the perfection of condition, and as a great delicacy. The method for detecting tyrotoxicon in milk and cheese will be found in the section relating to the examination for ptomaines and toxins.

NOTE.—Whilst these pages have been passing through the press the Medical Officer of Health to the London County Council has presented a report, prepared by Dr. Houston, on 'The Bacteriological Examination of Milk,' in which he describes the processes adopted in examining about 100 samples of milk from different sources, and makes certain tentative suggestions as to standards. The report also contains diagrams of the apparatus used.

CHAPTER XXIV

UNSOUND FOOD. FRUIT, VEGETABLES, AND CORN

Ripe fruits usually begin to suffer change, chiefly of a fermentative character, soon after being gathered, especially if of a pulpy nature, or if bruised, and readily become affected by moulds. If markedly mouldy or if the fermentative processes are advanced the fruit should be considered 'unsound.' The conditions under which a large proportion of fruit is gathered during the season render it surprising that more cases of specific disease have not been reported as due to the fruit having become infected. Probably fruit does not form a favourable culture medium for pathogenic germs. The ordinary fermentative changes which are observed in fruits apparently do not give rise to deleterious substances, or not until decomposition is so far advanced that the fruit is unsaleable. Toxins may undoubtedly be formed by catabolic changes in the proteid constituents of fruit, but, as far as we are aware, no investigations have been made on the subject.

As mentioned elsewhere, preservatives are frequently added to fruit and fruit products to prevent fermentation and the growth of moulds. It is scarcely conceivable that the spores either of moulds or of bacteria could withstand the boiling which the fruit undergoes in jam-making, but in transferring from the pans to jars, and in the process of covering, &c., yeasts, moulds, or bacteria may gain access, and in the absence of antiseptics set up fermentative or other changes.

Vegetables.—In connection with vegetables eaten in an uncooked condition, such as water-cress, lettuce, and celery, two classes of disease have been reported: namely, typhoid fever

and hydatid disease. Many water-cress beds are liable to sewage pollution, and an epidemic of typhoid fever appears to have arisen from water-cress grown in certain beds in Essex. In 1903 Dr. J. King Warry,[1] Medical Officer of Health for Hackney, reported that 110 cases of typhoid fever arose during the months of June, July, and August, a considerable proportion of the patients having partaken of water-cress from certain beds. Two waves of disease occurred; in the first, there were forty-eight cases within a radius of one-third of a mile of a certain centre, 64·4 per cent. having eaten water-cress at a period fitting in with the usual incubation period of the disease. The second wave involved some sixty-two persons within a radius of half a mile of another centre, and of these 55·3 per cent. had eaten water-cress. It will be noticed that the months (June to August) are not those in which typhoid fever is most common, and some especial cause was, therefore, indicated. Seventeen different samples of water-cress were submitted to bacteriological examination (six of them being derived from West Ham), and all of them were found to be polluted by sewage organisms. A sample of water from one of the West Ham beds contained no less than fifty specimens of B. coli communis per c.c.

Hydatid disease, due to the cystic form of Tænia echinococcus, has already been described. Though not very common in England, patients so suffering are admitted from time to time to the hospitals for operations. It is obviously impossible to trace the exact sources of infection, but from the known history of the parasite there is little doubt that the ova have been conveyed to some vegetable articles of food usually eaten in a raw state, such as water-cress and celery, by the fæces of dogs or other animals, which act as hosts to the tapeworm.

Mushrooms are, in the autumn, a very favourite article of food, and rarely a season passes without cases of mushroom poisoning being recorded. These cases differ very much in character, and it is impossible to say whether they arise from

[1] *Lancet*, 1903, ii. p. 1,671.

the accidental admixture of poisonous fungi with the true mushrooms or from some abnormal quality of the mushrooms themselves. In any case mushrooms admixed with other fungi of unknown character should not be sold, and mushrooms presenting decided signs of decomposition or any other abnormal character should not be used for human food. The edible mushroom, Agaricus campestris, and its varieties, may be recognized from the following description, and any fungi not corresponding thereto should not be permitted to be sold as mushrooms. It has a characteristic pleasant odour, the cap is fleshy and fairly thick compared with the gills, and its upper white surface is speckled with grey. It 'peels' very easily. The stalk grows from the centre of the cap, and does not produce any milky juice. Upon keeping the head does not become soft and wet. The gills vary in colour from a pale yellow-brown to a blackish-brown, and they are free from the stalk.

Many fungi are undoubtedly poisonous. Thus the Amanita muscaria, or fly fungus, contains the toxic alkaloid muscarine, which is allied to the ptomaines (*vide* p. 309). The Amanita phalloides contains a poisonous principle closely related to the toxins. Most fungi contain a rather large proportion of proteid matter, that in the edible mushroom averaging about 17 per cent. Possibly in some cases this may undergo a change with the production of ptomaines or toxins, and as this change may not have occurred in all alike, certain mushrooms may be poisonous and others not. This would explain those cases in which in a family partaking of the fungus some members have afterwards exhibited symptoms of poisoning and others have not. Personal idiosyncrasy may in some instances be a possible explanation.

In many cases vomiting and diarrhœa supervene soon after the mushrooms are eaten, and the poison is eliminated. Usually, however, the symptoms do not appear for some hours, or not until the day following. These symptoms may be of the gastro-enteric or neurotic type, or possibly both may be

present in the same patient. Dixon Mann[1] gives the following description of these symptoms:

'Gastro-enteric symptoms may not appear for six or ten hours after the fungi are eaten, and not unfrequently they are still further delayed. A feeling of uneasiness in the stomach gradually develops into pain, with a hard, tender condition of the abdomen, nausea is experienced, and then vomiting, which is followed by diarrhœa. The vomiting and diarrhœa are not solely due to the immediate presence of the irritant, but to the condition set up by it in the gastro-intestinal mucous membrane; therefore they do not at once subside when all the fragments of fungi are discharged. The enteric derangement is further shown by the character of the evacuations, which are serous, like rice-water, and contain flakes of lymph, and sometimes blood; notwithstanding treatment, the diarrhœa and vomiting may persist for several days. Great thirst, prostration, shrinking of the tissues, livid countenance, cold surface, small pulse, and laboured respiration are the natural results of the excessive drain on the blood; exceptionally jaundice may occur.

'These symptoms may directly lead to death, with or without the appearance of any special nerve complications, or they may subside, and recovery may take place.

'Neurotic symptoms comprise muscular twitchings, general convulsions or tetanic spasms, delirium, disorders of the special senses especially of vision, with dilatation of the pupils, and stupor, or profound coma. In some cases the symptoms are solely neurotic; such cases present all the appearances of certain forms of alkaloidal poisoning.'

Possibly mushrooms may cause a train of symptoms of an entirely different character, to which attention has recently been directed by Mr. Jonathan Hutchinson in a letter to the 'British Medical Journal.' He says, 'It is, I believe, generally supposed that if a fungus disagrees it does so by causing stomach and bowel symptoms, and that the onset of these is

[1] *Forensic Medicine and Toxicology*, p. 645.

speedy. Neither of these statements is true. The symptoms of fungus poisoning vary exceedingly in character (as probably do the poisons which excite them), and it is a most peculiar feature in some of them that their incidence may be delayed for very considerable periods. This latter circumstance ha no doubt led to the non-recognition of the true cause of many attacks of illness which were really due to meals which had been taken several days previously.' He then asks, 'Putting aside all cases of mere stomach and bowel disturbance, which are common enough and easily assigned to their causes, have cases been met with frequently during the last few months in which the principal symptom has been severe pain, referred chiefly to the walls of the chest and abdomen, without sickness or diarrhœa? The pain in the cases to which I refer is very severe and peculiar, and is never described as griping, and it is such as to suggest to the surgeon the passage of a gall stone, and it is sometimes followed by slight jaundice and bile in the urine, which may seem to confirm that suspicion. There is never, however, any special tenderness over the gall bladder, and sickness may be wholly absent. I have good reason to believe that the whole group may be caused by sound mushrooms, and that there may have been an interval of forty-eight hours or more between the meal and the first occurrence of pain, during which time the unsuspecting victim may have felt in perfect health.'

Dr. Plowright believes that practically all the deaths which occur in this country from the eating of fungi are caused by the consumption of one species, and one species only, and that they result from the mistaking of this particular species for the common mushroom, which it to a certain extent resembles. This is the Amanita phalloides, already referred to as containing a powerful toxin, to which the name phallin has been given. The following description of this very poisonous fungus is by Dr. Plowright.[1] 'A phalloides is never anything else but white under the cap, where everybody knows the mushroom

[1] *British Medical Journal*, September 9, 1905.

is pink, purplish brown, or almost black. On the top phalloides is frequently nearly white, but one can always see traces of yellowish green, especially about the margin. The stem of the mushroom is nearly cylindrical—that is, nearly as thick above as it is below—but the stem of phalloides is always bulbous, and springs out of a cup made by the upper part of the bulb, the so-called "poison cup." It peels almost as well as the common mushroom.'

Eighteen deaths have been recorded from the use of this fungus since 1900 in France alone.

Cereals.—The parasites which may affect wheat and wheaten flour, rendering it unfit for food, are of two classes, animal and vegetable. Of the former the corn weevil (Calandra granaria), the meal mite (Acarus farinæ), and the ear cockle (Vibrio or Tilletia tritici) (Plate VI.) are the commonest. The weevil attacks the shell of the grains and abstracts the flour while the corn is standing. The ear cockle likewise affects the standing corn; the grains become misshapen, greenish, and subsequently black; they are filled with a white cotton-like substance, which, when moistened and examined under a microscope, is found to consist of the larval form of the worm in a state of activity. The Acarus farinæ, which bears a superficial resemblance to the Acarus scabiei, is found in damp flour, which should then be regarded with suspicion as possibly unwholesome.

The vegetable parasites (Plates VI. VII. and VIII.) include Penicillium glaucum, Aspergillus glaucus, Mucor mucedo, Puccinia graminis (rust), Ustilago segetum (smut), Tilletia caries (bunt), and Claviceps purpurea (ergot). The first three common moulds occur in damp grain, indicating that it is unfit for food. Rust attacks many varieties of corn. A spore attaches itself to the grain, sending filaments into the interior from which is developed a dense mycelium, and as the result of its growth the cuticle ruptures, and the spores are found on the surface as 'rust.' Smut and bunt attack growing corn in a similar manner, replacing the starch grains by

mycelia and spores. Smut chiefly affects barley and oats, and bunt affects wheat. Claviceps purpurea, which attacks rye, is a more important parasite from the medical point of view, as if present in any quantity it is capable of giving rise to ergotism. The ascospores of this parasite are carried to the rye flowers by the wind, and form a mycelium of delicate hyphæ in the ovaries. As the grain ripens the hyphæ invade and absorb the whole of the starch, until the mycelial growth bursts through the pericarp and appears like a spur, two or three times the size of the rye grain, projecting from the spike. It finally becomes dissociated from the grain and falls to the ground. The ergot grains are purple externally, whilst the interior is of a cream colour, consisting of a dense network of hyphæ. Two varieties of ergotism are generally distinguished, the spasmodic or convulsive, and the gangrenous, according to the symptoms which predominate. The first variety, which is more common in children, is acute in character, the initial vomiting being followed by colic, purging, and convulsions, often quickly ending in death. In the gangrenous form, dry gangrene, due to the action of ergot on the blood-vessels, is the predominating symptom, and may be preceded by an erysipelatous flush, and be accompanied by intense pain. Ergotism in its epidemic form is now almost extinct, though it is by no means uncommon in Russia. Pellagra, occasionally met with in North Italy, Roumania, France, and North Spain, is due to the action of 'verdet,' the spores of Reticularia ustilago, on maize (Plate VIII.). The symptoms consist chiefly of digestive disturbances, and patches of erythema, occurring principally on surfaces exposed to the sun. In severe cases petechiæ, bullæ, and ulcers may arise, to be followed by paralysis of the limbs. After recurring attacks melancholia or mania may supervene, whilst tremors and epileptiform seizures are not uncommon.

Lathyrism is a rare disease, occurring, among other places, in the departments of Loire and Chur, in Abruzzi, and in Allahabad. It is apparently associated with certain

fermentative changes in the Chick Pea or allied pulses, the chief symptoms being those of spinal paralysis, principally affecting the lower part of the cord.

Formerly it was not uncommon to find seeds of Darnel grass (Plate VII.) mixed with flour, accidentally or fraudulently, and as a result cases of poisoning have occurred, the symptoms being giddiness, tremors, vomiting, and convulsions. The starch granules resemble those of wheat, but the testas of the two grains show considerable differences. Pure flour, when mixed with alcohol, forms a straw-coloured fluid, whilst if Darnel grass is present, there is a greenish solution possessing a repulsive taste, and, on evaporation, a resinous yellow-green extract is left (Parkes).

Mouldy flour (Plate VIII.) is rightly considered to be unfit for food, though as far as we are aware no cases of illness, comparable with those produced by flesh foods, have been definitely traced to spoilt flour, but it is extremely probable that it is capable of causing gastro-intestinal disturbance. Mouldy bread is known to have caused illness, and deaths have been attributed to the use of mouldy black bread.

Although illness is rarely traced to the use of cereals, it is possible that the omission is due more to defective observation than to any immunity from disease-producing powers possessed by such foods. In the Ohio Hospital for Epileptics, Gallipolis, U.S.A., an epidemic characterized by gastro-intestinal disturbance occurred in 1901, 218 of the inmates being affected. The cause was believed to be a batch of oatmeal which had been contaminated by dust derived from the road. A bacteriological examination of the flour indicated the presence of the B. coli communis and of the Proteus vulgaris.[1]

Maize, (Plate VIII.), **corn, rice,** &c., occasionally arrive in this country in an unsound condition, chiefly damaged by damp. Such materials may not be considered fit for human food, but they are rarely so affected as not to be usable by cattle, and their use for feeding purposes may be permitted.

[1] *Public Health,* xv. p. 279.

Meals and flours may on occasions require further examination. There are many varieties prepared in this country or imported from abroad, differing in the degree of fineness to which they are reduced, and in the portions which have been removed by sifting. Some also have been exposed to heat so as to render more or less of the starch soluble, and instead of being reduced to powder may merely have been crushed by passing between rollers.

A microscopical examination is only necessary where the odour, taste, or appearance of the flour indicates something abnormal. Under a low power search may be made for meal mites, Vibrio tritici, &c., and a little higher power used for the spores of moulds and fungi. If any appreciable number of the above organisms are found, the meal should be considered unsound. The same would apply if ergot is detected. Every flour must contain some small proportion of foreign seeds, the amount depending upon the cleansing of the corn. It is very doubtful, however, whether the seeds of any poisonous weed can be present in such quantity as to do harm. No recent record of any such instance is discoverable.

The cereals and their flours, whilst frequently attacked by moulds, do not appear to be favourable for the propagation of bacilli. Klein and Houston, for instance, found that typhoid and diphtheria bacilli and the vibrio of cholera soon died off in media composed of the flours of wheat, oatmeal, and rice.[1] The same observers examined six samples of wheat, six of oats, and two of rice obtained from wholesale firms. Spores of B. enteritidis sporogenes were present in each case, whilst bacilli resembling a typical species of B. coli communis were detected in many of the samples of wheat and oats.[2] The source from which these organisms, usually considered to indicate sewage pollution, is derived is uncertain. Possibly they were introduced through dust derived from the streets.

Bread is only likely to be unsound from having been kept until stale and mouldy, and in this condition is not likely to be

[1] *Local Government Board Report*, 1900-1. [2] *Ibid.* 1899-1900.

exposed for sale, though it may become an ingredient in such prepared articles as sausages, when mould, &c., if present would be detected by the microscope.

Baking does not thoroughly sterilize bread, and bacteria and moulds may be cultivated from the central portions of a loaf. These, doubtless, are in most cases derived from the flour, but their number may be increased by insanitary methods of kneading, baking, &c. Cockroaches infest many bakehouses, and it is not an uncommon occurrence to find portions of these animals in bread. Probably such a condition, implying carelessness and want of cleanliness on the part of the baker, would justify the opinion that the bread was unsound.

Fruit unsaleable in the open market is frequently sent to the jam factory, and it is often difficult to decide whether it is wholesome or not. In transit the softer fruits become pulpy and fermentation commences, but this alone is not sufficient in our opinion to justify seizure. If a fair proportion of the fruit appears to be rotten, or mouldy, or infested with maggots, it is certainly unfit for food. During certain seasons the raspberry is infested with the caterpillar of the raspberry moth (Lampronia rubiella), and the fruit contains so many of them, that one of us has not hesitated to condemn large quantities of imported fruit on this account. After being made into jam it is impossible to detect the presence of such foreign matter, but moulds and their spores may often be recognized, the boiling process having failed to effect complete disintegration (Plate VIII.). Probably by a microscopical examination the fact that the jam had been made from mouldy fruit could be ascertained. A layer of mould may have formed upon the surface of the preserve, but if the contents of the jar are otherwise sound this has no significance; it certainly would not justify seizure.

Tinned fruits and vegetables rarely require microscopical or bacteriological examination, and it is well to remember that such fruits, &c., are not always absolutely sterile. Probably spores may have resisted the action of the preserving process, and so long as these have not developed in the food, but have

remained quiescent, their presence does not necessarily imply unsoundness, and unless it can be shown that they are spores of an organism likely to injuriously affect the health of the consumer, seizure would be unwarranted.

Articles of vegetable origin rarely require more than a physical examination; usually the appearance alone is sufficient guide, though where the normal appearance is lost there will generally also be some difference observed in colour, taste, or odour, confirming the fact that the food has become unsound. Fruits, dried or undried, found in a damaged condition, may be unfit for human consumption; the greater the change from the normal, the more likely is the food to be deleterious. The presence of moulds or of fungoid growth indicates a degree of change sufficient to render the food unwholesome. It is very difficult to come to a decision when a portion only of the fruit is unsound, as when a small number of the bananas on a bunch are rotten, the remainder being fully ripe. If there is sufficient in a good condition to pay for the whole being picked over, there is no reason why this should not be permitted. To destroy, say, a whole cargo because a portion is bad is scarcely justifiable. Some articles arrive in this country in an uncleansed condition, and in such a state they are unfit for use; but the manufacturer has the material so treated as to remove all the foreign matters, when the remainder becomes perfectly wholesome.

CHAPTER XXV

FOOD-POISONING

In the great majority of cases flesh food is seized on account of its exhibiting signs of incipient decomposition, and it is frequently found that this change is taking place more rapidly than usual because the animal from which the flesh was derived was suffering from some disease, or prior to slaughter had been in a very exhausted condition. Flesh exhibiting these early signs of putrefactive change should be unhesitatingly condemned, the risk of poisoning being too great for us to depend upon cooking to render the food wholesome.

It will be found, however, in the following pages, that on many occasions food, apparently perfectly wholesome, has after cooking developed poisonous properties, and that preserved cooked food frequently gives rise to cases of so-called 'ptomaine' poisoning. In fact, most of the cases which have come to our knowledge have been due to the eating of tinned meats, but as such outbreaks, as a rule, only infect members of one family, and rarely prove fatal, they are not recorded, though occasionally they are noticed in the local press.

Few of the larger outbreaks of food-poisoning have been attributed to preserved foods, but, as has been stated, most of the smaller outbreaks have been due to the use of such foods, tinned meats and fish being especially prone to cause illness. In probably all cases this has been due to some change which has taken place in the food after it has undergone the preserving process, and it is difficult to see how sufficient supervision can be exercised to prevent these cases occurring. It is impossible to ascertain whether the meat was sufficiently

sterilized, or whether the food was in a fit state for consumption before the containing vessels were sealed, and unless the tins are 'blown,' the inspector rarely has any reason for seizing them and making a further examination. When the ends of the tins are convex outwards, and gas issues from a prick made in the end, the can being preferably under water, there can be no question that some decomposition has taken place, and that the food is unsound and should be seized and condemned. An unscrupulous dealer may prick the blown tins, and after reheating, seal them up again. Any tin which has been twice soldered should therefore be regarded with suspicion. Where illness has been caused by the consumption of such food, the inspector would be justified in purchasing other tins from the same vendor and examining them, provided there were sufficient grounds for assuming that the meat had not been infected after removal from the receptacle in which it had been sold.

After opening the tins the surface of the meat and the condition of the jelly should be carefully examined. Any abnormal odour or taste or appearance, especially if associated with liquefaction of the jelly, would indicate unsoundness, and therefore that the food was dangerous for use by man. Many cases of ptomaine-poisoning from tinned meats have occurred in which it has been declared that nothing abnormal was observed, but in other cases some peculiarity was noted, such as a 'soapy' taste, a sickly odour, discolouration of the flesh, or liquefaction of the jelly.

Meat from all kinds of animals has given rise to cases of poisoning. In many instances, especially on the Continent, the flesh has been found to be derived from an animal suffering from disease, but in the majority of cases such an origin has not been traced.

The flesh of swine is responsible for a large number of the serious outbreaks of food-poisoning which have occurred both in this country and on the Continent. In Germany the pork has usually been consumed in the form of sausages, but as

blood and the internal organs of animals are often used in the manufacture of such delicacies it is not always easy to determine which constituent is responsible for the ill effects produced. Dr. Ballard[1] investigated fourteen outbreaks in this country. Ten of these were due to pig-meat of one kind or another, one was due to veal, one to beef, one to butchers' meat (kind unstated), and one to tinned salmon.

As early as 1888, the Medical Officer of the Local Government Board said (19th Report, p. 13): 'The phenomena which we speak of as "food-poisoning," productive now of one and now of another sort of definite malady among consumers of certain foods, are claiming, on ever-growing evidence, to be regarded as true infective diseases, as much so as scarlatina or tuberculosis.' In other words, he regarded these outbreaks as being due to the action of specific organisms, and Dr. Ballard, as the result of his later investigations, supports this view, regarding 'the accession of the specific bacillus as what we commonly call "accidental," which,' he says, 'means that in this case it comes from somewhere beyond our present knowledge.' Below will be found a brief account of the more interesting outbreaks described by Dr. Ballard. For more complete details the original report may be consulted.

One of the most interesting of these outbreaks followed the use of tinned meat and occurred at Oldham. A shopkeeper opened a 7-lb. tin of American pigs' tongues, and within half an hour effected three sales of a quarter-pound each, all from the top of the tin. No more was sold, since the remainder was seized by the sanitary authority and used for analysis and experiment. All the persons who partook of the portions sold were almost immediately nauseated, and most of them suffered from diarrhœa and subsequent collapse. The collapse was greatest when the patient suffered least from diarrhœa, and the most severe case was that of a person who had no diarrhœa. Those who ate the first slice of the meat suffered most severely. Dr. Klein fed a number of animals

[1] *Report of Medical Officer, Local Government Board*, 1890.

with the remainder of the meat without injury. Dr. Ballard[1] therefore concludes, 'either that the poison that so severely affected persons eating meat from this tin had disappeared from the material by keeping a few days, or it had been originally confined to that end of the tin which was first cut from. It is noteworthy that, in this case, there was something obviously wrong with the meat, since it is stated that 'one purchaser, finding the food bad, threw it away.'

The Whitchurch outbreak, also referred to by Dr. Ballard, is interesting from the fact that roast leg of pork was eaten hot on Sunday for dinner, and cold for supper, without producing illness, but when eaten cold on Monday it made the people ill. Two persons died from its effects after thirty hours' illness.

Another interesting outbreak referred to by Dr. Ballard occurred at Retford, eighty persons being attacked, one case proving fatal. The pork was made into pies and brawn. With the exception of one family, none who ate of this food-stuff on the first day after cooking were taken ill, and none who ate it the fourth day after cooking.

In the Portsmouth outbreak, due to cold meat pies, the pies when first received by Dr. Klein proved poisonous to mice, but five days later, when the material had become offensive from putrefaction, they were no longer toxic.

The largest and most extraordinary outbreak recorded occurred in 1888 at Middlesbrough, when some hundreds of persons were attacked with pleuro-pneumonia, and many died. Ballard, as the result of a most painstaking investigation, came to the conclusion that it was due to the use of American bacon, all the samples collected proving poisonous to rodents.

Ballard suggests that pigs' meat owes its unenviable pre-eminence as a cause of food-poisoning to the fact that it furnishes a large proportion of gelatine, jelly being a most favourable medium for the growth of pathogenic bacteria. His

[1] *Local Government Board, Report of Medical Officer*, 1890.

final conclusion, on summing up the whole matter, is eminently practical. He says: 'What does it all indicate as an efficient precaution against food-poisoning? Of course no one is likely to be hindered by any fear of infection from eating cold ham or gelatinized food of any kind, if he likes them. But if we do eat ham or bacon, cold or warm, it is a proper precaution to avoid them if not duly cooked throughout. The people who chiefly got pneumonia in Middlesbrough were a class who habitually only warmed the bacon they ate, by slightly toasting it before a fire; they did not heat it sufficiently to kill any micro-organism, and hotel hams (indeed hams cooked at home too) are rarely thoroughly cooked. But the grand precaution of all is the very commonplace one, signified by the word cleanliness. Every factory where pork is converted into brawn or hams ought to be so arranged that light and a draught of air can penetrate freely everywhere; there should be no corners where refuse matter can lodge and become a centre for the cultivation of morbid micro-organisms in filth, the rise of ground air should be obviated by cement under the pavement or flooring, the place should be kept scrupulously clean, and free from incursion of sewer air or unwholesome emanations of any kind. Kitchens, and above all pantries and places where food is stored in hotels, public refreshment rooms, or pastry-cooks' premises, and in private houses, should be similarly cared for. It should be held to be part of the business of conservators of public health to see that these rules are observed, as well as the business of every master or mistress of a family.'

The immediate causes of these epidemics of 'food-poisoning' have only been investigated with any degree of completeness in comparatively recent years, and until lately the classification of the associated bacteria has been very imperfect; but the work of Gärtner, Van Ermengem, Klein, Delépine, Durham, and others, has thrown a considerable amount of light on this somewhat obscure subject.

All proteid matter, whether of animal or vegetable origin,

when suffering decomposition gives rise to the formation of small quantities of bodies possessing the chemical properties of the alkaloids, and to these chemical entities of animal origin the name of 'ptomaines' was given by Selmi. Those derived from the cadaver were first discovered by Gautier in 1872, and a large number of them have since been isolated, and those having very definite chemical or physiological properties have received names. Long before the actual isolation of these alkaloids it had been remarked that in many cases of poisoning by decomposing or unwholesome meat the symptoms resembled those caused by certain vegetable alkaloids. Thus, in 1820, Kerner noticed that persons who had been poisoned by eating certain sausages presented the symptoms of poisoning by belladonna, the active principle of which is the alkaloid atropia. Since the discovery of the 'ptomaines' the majority of cases of food-poisoning has been accredited to the action of these alkaloids, hence the frequency of so-called ptomaine-poisoning. When this term is used, the inference is that the ptomaines already existed in the food eaten, produced during some change the food had undergone, and to such cases, strictly speaking, should the term be restricted. In many cases, however, the poisonous substances are produced afterwards in the body, by the action of microbes introduced into the stomach with the food. The patient is as certainly poisoned in the one case as in the other, but, the processes being different, they should have different names. The former is an 'intoxication,' the latter an 'infection.' Referring to the production of 'ptomaines' and their virulence, Brunton states that 'The alkaloid products formed by the putrefaction of albuminous substances vary according to the stage of decay at which they are produced. At first the poisonous action of these products may be slight. As decomposition advances the poison becomes more virulent, but after a longer period they appear to become broken up, and lose to a great extent their poisonous power.' It must not be assumed, however, that poisonous substances are only formed when the decomposition is of a

putrid character, as such is certainly not the case. Neither is the presence of bacteria absolutely essential for the production of ptomaines, as Brieger has isolated an alkaloid from the products formed when fibrin is digested by means of pepsin, and in many cases of ptomaine-poisoning the food has exhibited none of the usual signs of incipient putrefaction. Almost certainly also ptomaines and allied substances are being continuously formed within the body, but health is maintained so long as these are non-toxic or are not produced in quantities greater than the system is capable of eliminating.

The more poisonous ptomaines which have received names are muscarine, neurine, choline, mydaleine, and sepsine. According to Brunton, muscarine, neurine, and choline have a similar action, muscarine being the most and choline the least powerful. All produce 'salivation, diarrhœa, vomiting, dyspnœa, paralysis and death.' Mydaleine causes a rise of temperature, 'dilatation of the pupil, enormous secretion of tears, saliva, and sweat, vomiting, diarrhœa, paralysis, convulsions, twitching, dyspnœa, coma and death.' Sepsine causes 'vomiting, diarrhœa, and bloody stools.' Other alkaloids resembling atropine and curare have been isolated, and from putrid maize a substance can be obtained with a narcotic and tetanic action, but Brunton thinks these effects may be due to two distinct alkaloids.

It is exceedingly doubtful, however, whether the ptomaines ever occur in food-products in sufficient quantity to produce poisonous effects. In practically all cases, when a substance is being examined for ptomaines, it is found that the liquid containing them is far more poisonous than the alkaloids isolated therefrom, and many ptomaines which have been isolated have little if any deleterious effect upon the system. It is not surprising, therefore, that many now hold the opinion that the term ptomaine-poisoning is a misnomer, and that the poisons produced in food-stuffs from the proteid matter therein are not of the nature of alkaloids. To these poisons the generic term of 'toxins' has been applied, and they appear to

be more nearly related to such active principles as ricin and abrin occurring in certain plants, and with venin, the active principle occurring in the venom of various species of snakes, the chemical nature of which remains as yet unknown.

The toxins produced by bacteria are probably not all of the same nature, but belong to different groups, some being comparable with ferments, and others with the albumoses, bodies formed at an early stage in various digestive processes. Uschinsky's researches indicate that some, if not all, the toxins are synthetic rather than analytic products, as he has succeeded in preparing virulent toxins by growing bacteria in fluids free from proteid matter.

Certain bacteria, after death, are found to be extremely toxic, and in such cases the toxin must be contained within the bodies of the organisms. These are called 'intracellular' toxins to distinguish them from the toxins found in the fluids in which bacteria are developing.

The poisons produced in culture media may be first formed within the body of the bacteria, and then be excreted or pass into the liquid only upon the death and disintegration of the micro-organisms producing them. On the other hand the culture fluid may become extremely toxic, whilst the bacteria themselves remain practically free from the poison. The toxins appearing under such circumstances are called 'extra-cellular.' In some cases the toxin contained in the bodies of the bacteria differs in its properties from that produced in the culture medium, the organism apparently producing two distinct toxins, one intracellular and the other extracellular. Some of the toxins—as, for example, that of tetanus—are incomparably more deadly than any known alkaloid. When introduced into the system the symptoms of poisoning may not occur immediately, in fact they may be delayed for many hours; hence the question arises whether these are not bodies allied to ferments, possessing little if any toxic power in themselves, but capable of the continuous production of powerful poisons when introduced into the system. At present, how-

ever, it is generally held that there is no decisive evidence to prove that any poison is so produced, and the delay in the production of symptoms admits of other explanation.

Whatever the nature of the poisons it is evident that the pathogenic bacteria may produce them: (*a*) in the food before its consumption; (*b*) in the body after the food has been eaten; or (*c*) they may produce a certain amount of poison in the food, and afterwards continue the production of poison after ingestion. In case of (*a*), and possibly in that of (*c*), the poison may admit of isolation from the food, providing sufficient remains for this purpose, whereas in (*b*) no poison would be found in the food, though the organism producing it might be detected, and its ability to produce ptomaines or toxins ascertained by experiment.

The symptoms due to eating food in a state of decomposition are probably caused in some instances by the bacterial products, formed in the food-material prior to ingestion, and therefore are true 'intoxications'; but the large and serious epidemics of meat-poisoning, which have been recorded both in England and on the Continent, are more frequently of the nature of 'infections.' In the absence of a complete bacteriological and chemical examination it is not always possible to draw a distinction between the two processes, and the probability of both toxins and organisms being present together must be borne in mind. The chief criterion usually cited for drawing a distinction between the two processes is the presence or absence of an appreciable 'incubation period,' but this period in the case of certain infections may not exceed a few hours, whilst, in the presence of both bacteria and their toxins, symptoms due to the latter may be noticed almost immediately to be subsequently merged into those due to the infection. A temperature of 60° C. should be sufficient to destroy most of the bacteria known to be associated with meat-poisoning, whilst toxins are likely to be more resistant, many of them retaining their properties after boiling; but it has frequently been shown that the interior of a pie or

other article of food may not reach the temperature mentioned, even though the food has been subjected to a process of cooking, hence in cooked foods the ill effects may be due to bacteria which have escaped the action of the heat.

Durham[1] lays considerable stress on the association of meat-poisoning with bacteria rather than with their products; and he points out that the dose of toxin necessary to produce the symptoms recorded would require to be a large one, and that in nearly every instance in which an outbreak has been investigated bacteriologically, certain special organisms have been found.

With reference to food-intoxication, Martin[2] indicates that when putrefaction of meat takes place, there is a formation of gas, such as carbonic acid, hydrogen, nitrogen, sulphuretted hydrogen, and marsh gas; of acids, such as formic, acetic, lactic, and butyric acids; of ammonia, amines, albumoses; and of certain compounds of the aromatic series, such as skatol and indol. (The so-called ptomaines are alkaloidal bodies of the amine class.) The more toxic bodies are apparently formed at an earlier stage than the substances possessing a disagreeable odour, and poisons may therefore be found in meat which is apparently fresh. The pyrexia which is frequently noticed Martin regards as being probably due to certain albumoses, which are also formed early in the process of decomposition.

During recent years many outbreaks of food-poisoning have been very fully investigated bacteriologically, and the particular bacteria believed to be responsible for the production of the ptomaines or toxins have been isolated and fully described. The majority of these belong to the group of which the Bacillus coli communis is the most prominent member. Unfortunately, in the earlier outbreaks, bacteriological knowledge was not sufficiently advanced to enable the bacteria isolated to be identified.

One of the most important group of cases is due to the products of the Bacillus botulinus, first described by

[1] *British Medical Journal*, 1898, vol. ii. p. 1,797.
[2] Clifford Allbutt, *System of Medicine*, vol. ii.

Van Ermengem, which produces 'botulism.' The food particularly associated with the disease is pork, especially in the form of sausages. The bacillus is an obligatory anaërobe, which forms spores, and is slightly motile; it grows best in an alkaline medium, and at a temperature between 20° and 30° C. It ferments glucose, but does not curdle milk. It is pathogenic to monkeys, guinea-pigs, &c. Its growth is checked by common salt when present to the extent of 6 per cent., and even the spores are said to be destroyed at a temperature of 80° C. The toxin which it forms, though extremely virulent, is apparently rendered inert at a temperature of 70° C.[1] The symptoms as a rule occur almost immediately after the meat is eaten, and consist chiefly of malaise, bodily pains, vomiting, constipation and prostration. Diarrhœa is rare, and, if present, does not generally arise till the second or third day. The most remarkable characteristic is, however, a more or less complete external or internal ophthalmoplegia, leading to loss of vision, diplopia or strabismus. Pyrexia is as a rule absent, and death may occur with symptoms resembling bulbar paralysis. The mortality is often high, sometimes rising to 30 or 40 per cent.[2] Many outbreaks due to this organism have been recorded in Germany, but it is probable that some were true 'infections,' as the symptoms often did not appear within less than twelve hours after ingestion of the poison and often as late as twenty-four hours afterwards. It is noteworthy also that meat may be so affected by this bacillus as to be extremely poisonous, without any of the ordinary signs of decomposition being apparent.

In connection with the subject of toxins reference may be made to the views of Dr. Vaughan Harley and others, that scurvy is due to the consumption of food which has undergone some fermentative change. The evidence of this relationship is, however, by no means established, and certain outbreaks which have been recorded can hardly be explained on these grounds.[3]

[1] Ostertag, *Handbook of Meat Inspection.* [2] *Ibid.*

[3] *British Medical Journal*, 1902, i. p. 10; *ibid.*, 1905, i. p. 620; *Lancet*, 1904, i. p. 1,714.

The bacilli which are probably most frequently associated with epidemics of meat-poisoning are members of the B. coli, the B. enteritidis (Gärtner), and the 'paratyphoid' groups. It is only within recent years that the characteristics separating the last two organisms from the true Bacillus coli communis on the one hand, and the Bacillus typhosus on the other, have been worked out, and consequently the precise class under which the organisms, which have been isolated in some of the earlier epidemics (e.g. Welbeck), fall must remain undecided. The first exact bacteriological investigation of meat-poisoning was probably that made by Gärtner in connection with an epidemic at Frankenhausen in 1889. Fifty-nine persons became ill after eating the meat from a cow subjected to 'emergency' slaughter. The symptoms were severe gastro-enteritis, fever and prostration. The bacillus known by Gärtner's name was isolated both from the meat and from one of the fatal cases.[1] It produces a toxin which is not destroyed at the temperature of boiling water.

An account of some of the bacilli which have been found associated with meat-poisoning, together with their cultural and other characteristics, and their relationship with the organisms of psittacosis, hog cholera, dysentery, &c., has recently been given in a paper by H. de R. Morgan,[2] and he has shown that bacilli of both the Gärtner and paratyphoid group can be isolated from the excreta, and also from the scrapings of the intestinal mucous membrane, of normal animals. Bacilli of the former group were apparently scanty but virulent, and could only be isolated by the passage through a guinea-pig of a culture made from an emulsion of the substance under examination, whilst organisms of the paratyphoid group were comparatively abundant, and could be obtained directly from cultures.

In addition to the Frankenhausen epidemic already referred to, the B. enteritidis has been proved by Delépine[3] to be

[1] Ostertag, *op. cit.* [2] *British Medical Journal*, 1905, vol. i. p. 1,257.

[3] Report on outbreak of food-poisoning in Derby, 1902 (Howarth and Delépine).

responsible for the Derby outbreak of 1902, where pork pies were the source of infection, by Durham[1] for the Chadderton outbreak of 1898 (veal pies), and by various Continental observers[2] elsewhere.

The Chadderton epidemic may be taken as an example of this form of meat-infection. It occurred in July 1898, and was in the first instance reported on by Drs. Bowen and Ashton,[3] and subsequently by Dr. Durham.

The number of cases heard of in Chadderton was thirty-five, three of which were fatal, whilst twelve further cases with one death, occurring in the neighbouring town of Oldham, were apparently infected from the same source. The incubation period varied from three to twenty-nine hours, six to eight hours being the usual period. The symptoms included vomiting, diarrhœa, griping, thirst, pyrexia, and exhaustion. Colitis was the most noticeable feature at the autopsies. The food implicated consisted of a batch of veal pies, the confectioner making in all 268 pies, of which 160 were veal, and the remainder pork; the other batches were apparently harmless. The pies were said to be cooked for twenty minutes at a temperature of 400° to 500° F., but it is suggested by Durham that the batch concerned was insufficiently cooked, and that the interior especially had failed to reach the bacillary thermal death-point. This is rendered the more probable in that a portion of the meat in the interior of one of the pies examined appeared to have escaped the temperature at which the albumen should become coagulated. In every instance a period of about forty-eight hours elapsed between the time of cooking and the eating of the pie. Durham did not begin his investigations until too late a period to thoroughly establish the connection between the epidemic and the Bacillus enteritidis, but valuable evidence in this direction was obtained from the fact that the blood serum of every one of nineteen of the sufferers examined gave the specific reaction

[1] *British Medical Journal*, 1898, vol. ii. p. 1,787.

[2] 'Zur Ætiologie der sogenannten Fleischvergiftungen,' Professor Bernhard Fischer, *Zeitschrift für Hygiene*, vol. xxxix. 1902; Ostertag, *op. cit.*

[3] *British Medical Journal*, 1898, vol. ii. p. 1,456.

with cultures of Gärtner's bacillus, and a further indication that bacilli, and not toxins, were responsible, is that two persons were ill after eating sandwiches prepared in the same shop. As Durham points out, it is almost inconceivable that sufficient toxin could be transferred from the pies to the sandwiches, while contamination by bacilli readily explains the circumstance.

Durham also quotes experiments in which an ox was inoculated with B. enteritidis, killed and partially bled twenty minutes later. A few colonies of the bacillus were recovered from the spleen and liver, but none could be detected in the flesh nor in the blood. The meat was then kept at 20° C. for seventy-two hours, after which the bacilli were found in abundance, though they were only scanty when the meat was maintained at 5° C. Of fifty-three persons who, although warned, ate the meat, fifteen became seriously ill.

A bacillus resembling Bacillus coli was apparently responsible for an outbreak of illness in Sheffield in 1899. The meat implicated was a 6-lb. tin of corned beef: 4 lbs. of this were sold, chiefly in quarter-pound pieces, and some twenty-four of the consumers were ill, with vomiting, headache, colic, diarrhœa, and collapse. Half the patients were children under twelve, and one case proved fatal. The incubation period varied from one to three and a half hours.[1]

Bacilli apparently belonging to the B. coli group were found in connection with meat epidemics at Welbeck (1880), Nottingham (1881), and Middlesbrough (1881), pig meat being the food implicated in each instance. A virulent species of B. coli was isolated by Klein in an outbreak of poisoning at Mansfield in 1896. Potted meat was the vehicle of infection, and 265 persons were affected. The meat was freshly prepared, not tinned meat, and was eaten within a few days of cooking. The incubation period varied from five to thirty-six hours, and the symptoms resembled those in the epidemics already described. A variety of bacilli, cocci, and yeasts were isolated

[1] W. N. Barker, *British Medical Journal*, 1899, vol. ii. p. 1,367.

from the meat, and of these two forms—Proteus vulgaris and B. coli—were pathogenic to mice.[1]

In the Moorseele epidemic (1892) Van Ermengem isolated a bacillus from the bone marrow of two calves, whose flesh was responsible for the outbreak, belonging to the B. enteritidis group, but differing slightly from Gärtner's bacillus in its staining reactions It was pathogenic to calves, apes, dogs, guinea-pigs, rabbits and pigeons, and formed a toxalbumen, not destroyed by heating to 120° C.

In connection with an epidemic at Breslau, Flugge obtained a pathogenic bacillus of the B. coli type from the blood of mice that had been fed on the infected meat. The bacillus differed from true B. coli in not producing indol, and in not coagulating milk. It was probably of a similar nature to the Moorseele bacillus, and formed a toxin similarly resistant to heat.

An allied organism was isolated by Holst from the spleen and intestinal ulcers of patients who had died during an epidemic of meat-poisoning at Ganstadt.

In a similar epidemic at Denis, Kuborn obtained Staphylococcus pyogenes aureus, which he considered to be the cause of the illness.[2]

In all the epidemics we have mentioned, with the exception of that at Middlesbrough, the chief symptoms were gastric or intestinal or both. At Middlesbrough, however, the prevailing lesion was pneumonia. The epidemic was apparently associated with American bacon, from specimens of which Klein isolated a bacillus capable of causing pneumonia in rodents. Moreover an epidemic of pneumonia occurred among monkeys, mice, and guinea-pigs, kept in the building where the experimental work was carried out. The same bacillus was recovered from the organs of the animals.

It is a noticeable feature in the epidemics occurring in England that the history of the animal responsible for the outbreak has seldom or never been obtained. This lack of information, fostered by the system of private slaughter-houses,

[1] *Local Government Board Report*, 1897, p. 115. [2] Ostertag, *op. cit.*

is a considerable handicap to medical officers of health, since a knowledge of the kind of disease likely to produce these serious epidemics in man is absolutely necessary for the safety of the public. Some light is, perhaps, thrown on the subject by the experiments of Morgan, which we have quoted, and those referred to by Durham, and still more by the history of many of the Continental outbreaks.

In 1880 Bollinger read an important paper before a medical society in Munich, in which he reviewed all the principal cases of meat-poisoning that had been recorded in Germany and adjoining countries up to that year, and in which he included the researches of Siedamgrotsky comprised in a series of lectures to veterinary surgeons. A considerable number of these instances are detailed by Ostertag,[1] who extends the list up to the year 1898, and it is from his book that the accounts of the following outbreaks are derived.

The majority were due to the ingestion of meat from animals which had suffered from septic conditions. In 1867 an epidemic characterized by vomiting, diarrhœa, stupor, headache, delirium, and prostration, affected twenty-seven persons in Fluntern, Switzerland, after eating veal from a calf five days old which had 'yellow water' in the joints—probably a form of congenital pyæmia. Similar symptoms occurred in an outbreak in Bregenz in 1874, the meat being derived from a cow that had been subjected to emergency slaughter five days after parturition, on account of injuries to the sexual organs and retention of the placenta. Fifty-one persons were affected, the liver being apparently more toxic than the muscles, but both the meat and broth made from the meat were responsible for many of the cases. In Wurzen (1877) no less than 206 persons were poisoned by the meat of a cow which was slaughtered in a moribund condition on account of mammitis and paralysis of the posterior extremities. The meat was eaten partly raw, partly cooked, partly as sausages, and partly as pickled meat, within four days after slaughter. The

[1] *Op. cit.*

symptoms resembled those of cholera. A still larger epidemic occurred in Klaten (1878), 657 persons being affected, with six deaths. The outbreak was ascribed to the meat of a calf one week old, which had either died or had been slaughtered during the death agony. Two interesting points in this epidemic were that the veal appeared to have transmitted the infection to hams which had been stored alongside, and that secondary cases occurred, the infection being derived from the primary cases. This suggests that the illness was an infection and not an intoxication.

In 1887 an extensive outbreak of poisoning occurred in Middleburg, Holland, affecting 286 persons. The meat was derived from a cow which was slaughtered in a moribund condition, the placenta having been retained for nine days and having set up septic metritis. Cooking did not destroy the poisonous substance, and the effects appeared after periods varying from twelve hours to one or two days after ingestion. An outbreak occurred in Cotta, Saxony (1889), affecting 136 persons, with four deaths. The meat is said to have been normal in appearance and odour, and was derived from a cow subjected to emergency slaughter on account of mammitis.

An epidemic characterized by gastro-enteritis, and affecting forty persons, occurred in Bulstringen (1898), and was due to veal from a calf that had been the subject of inflammation of the joints and diarrhœa.

Next comes a group of cases in which poisoning resulted from the flesh of animals slaughtered on account of ill-defined diseases characterized by diarrhœa. Amongst these may be mentioned an outbreak at St. Georgen, near Friedrichshafen, affecting eighteen persons, the incubation period being two to three hours; an outbreak at Lauterbach in 1884, causing three deaths; an epidemic in Schönenberg, Switzerland, in 1886, affecting about fifty persons, with one death; a similar epidemic in Frankenhausen in 1889, with fifty-nine cases and one death. In this instance the cooked meat was injurious. When the cow was slaughtered the only abnormal condition

found was a slight reddening of the intestines. An outbreak at Piesenkam occurred in 1891, due to the flesh of a cow which had suffered from gastritis, enteritis, and cystitis. In the interesting epidemic which occurred in Moorseele, Belgium, in 1892, in which about eighty persons were affected after eating veal, the chief symptoms were vomiting, diarrhœa, and lassitude. The meat came from two calves, one of which had died, and the other had been slaughtered while in a diseased condition. Both calves had suffered from acute diarrhœa, and the intestines were of a dark-red colour, and the livers were swollen; the muscles appeared to be normal. The meat was eaten within twenty-four hours of slaughter, and it is said in every case in a well-cooked condition. The incubation period varied from three to twenty-four hours, though in one case at least forty-eight hours elapsed. In the Canton of Thurgau (1896) an epidemic of gastro-enteric catarrh affecting a number of persons was traced to cooked, pickled, and smoked pork, derived from animals slaughtered on account of a reddening of the skin and diarrhœa. In the same year forty-one persons suffered from symptoms resembling Cholera nostras in Sielkeim, East Prussia, the cause being traced to the flesh of two three-month-old calves slaughtered on account of diarrhœa associated with great depression. In the following year (1897) an epidemic characterized by similar symptoms affected forty-one persons in Kalk, near Cologne. The implicated meat was from a cow slaughtered on account of diarrhœa and general malaise. Illness was caused by the meat in both a raw and cooked condition.

As regards the more specific diseases, Ostertag mentions several instances in which ill results followed the consumption of the meat of animals suffering from foot-and-mouth disease or its sequelæ, but the symptoms of the victims resembled those described in the other epidemics.

Localized outbreaks of so-called ptomaine-poisoning are recorded almost weekly, especially during the summer months, and deaths so frequently occur that no excuse is needed for the

somewhat lengthy reference which has been made to this subject.

The histories of these outbreaks form a sufficient ground for regarding with grave suspicion the flesh of animals which have been slaughtered on account of the presence of some serious disease. Bacteriology has shown us that few of the bacterial diseases in man, formerly regarded as local, are in fact really so, and we may perhaps picture the steps leading up to an epidemic of food-poisoning as follows. A cow or pig is attacked with diarrhœa, possibly due to the Bacillus enteritidis, or an allied species, and some of the bacilli enter the general blood stream. The animal is slaughtered, and the flesh possesses the normal appearance. Probably at this stage no bacilli can be detected in the muscles, but a rapid multiplication takes place after death, when the circulation has ceased. The meat is cooked or made into pies, or pickled; the process is insufficient to destroy the bacilli in the interior, and an epidemic results; or it may be that whilst the bacilli have been killed the toxins produced have escaped destruction, and these may be present in sufficient quantities to produce poisonous effects.

CHAPTER XXVI

FOOD-POISONING (*continued*). EXAMINATION OF THE FOOD

When a sample of food alleged to be toxic is submitted for chemical examination, most careful inquiries should be made with reference to its source, the quantity consumed by the individuals affected, the intervals between the partaking of the food and the onset of the symptoms of poisoning, and the character of these symptoms. If considerable quantities of food were required to produce the ill effects, and it had been in contact with any metallic vessel, the possibility of the poison being derived therefrom might receive consideration, especially if the symptoms corresponded with those due to arsenic, lead, copper, tin, or zinc. It is, however, as we have stated elsewhere, absurd to attribute the poisonous effect to these metals because a trace can be detected in the food; and if only small quantities of the particular food submitted were required to cause illness, the probability of this being due to metallic contamination may be at once dismissed. The methods of detecting and estimating the various inorganic poisons which may occur in foods from the process of manufacturing, preserving, or from colouring, will be described in a later section; it remains only, therefore, to deal with the method of examination to be followed when the poison is suspected to be of bacterial origin.

The following facts must be borne in mind in making such an investigation, and in forming an opinion from the results obtained: (1) That the poison may not be uniformly distributed throughout the whole mass; (2) that changes may have occurred in the food since the poisonous portion was

eaten, whereby the toxic principle has been destroyed; (3) that any process requiring the use of acids or the aid of heat is likely to produce traces of substances giving many of the reactions of 'ptomaines'; (4) that results obtained by experiments on animals are not conclusive proof that the same results would be obtained with man; (5) that it is a waste of time conducting any chemical investigation unless a considerable amount of material is at disposal; (6) that many chemicals used, especially alcohol, ether, and chloroform, may contain traces of basic substances giving alkaloid reactions. These solvents should therefore never be used as purchased without previously undergoing careful examination.

Before commencing the chemical examination, feeding experiments should be made to ascertain whether the substance contains a poison or not, and to obtain an idea of its action and virulency. Mice may be used for this purpose, or kittens, or both. Rabbits and guinea-pigs are not suitable, since these animals cannot vomit. The fact of the food being poisonous having been demonstrated, an attempt may be made to isolate the toxic substance, ptomaine or toxin.

Processes have been devised for isolating ptomaines by Stas-Otto, Dragendorff, Brieger, Gautier, Etard, and others, but the Stas-Otto method, with proper skill, is undoubtedly the most reliable.

The substance to be examined is treated with twice its volume of 90 per cent. alcohol. If solid, or semi-solid, it must first be minced or triturated into a paste. Enough tartaric acid is then added, if necessary, to give the liquid a slight, but distinctly acid reaction, and the whole digested with frequent agitation at a temperature not exceeding 70° C. for several hours. The liquid portion is filtered and evaporated in a partial vacuum at a temperature not exceeding 35° C. The residue is exhausted with absolute alcohol, the solution filtered and again evaporated with the same precautions as before. The residue is now dissolved in a little water, filtered if necessary, rendered slightly alkaline with sodium carbonate,

exhausted with pure ether, and the ether allowed to evaporate spontaneously. The residue can now be tested for ptomaines, or, if thought desirable, further purification may be attempted by redissolving the residue in water, again extracting with ether, &c.

To small portions of the aqueous solution the following reagents may be applied, and the reaction obtained recorded. Unless the first two reagents give a distinct precipitate, ptomaines are either absent or present in infinitesimal quantities: potassium bismuthic iodide, potassium mercuric iodide, phospho-tungstic acid, phospho-molybdic acid, picric acid, tannin, iodine, platinic chloride, and gold chloride. If it is desired to ascertain whether the ptomaines correspond with any previously described, reference may be made to the tables in Vaughan and Novy's work on 'Cellular Toxins' or to Brieger's on 'Ptomaines.'

To examine for toxins, a filtered aqueous extract of the food-product is evaporated to a small bulk in a vacuum apparatus at a very low temperature, and the liquid supersaturated with crystals of ammonium sulphate. After standing in a shallow dish for twelve hours at a temperature of 37° C., a film or scum will be found upon the surface of the fluid. This, which contains the toxin, can be removed by means of a platinum spatula, placed on a watch-glass and dried in the dark over sulphuric acid, preferably *in vacuo*. The residue dissolved in water, or, better still, in normal saline solution, can be used for experiments on animals or for the application of chemical reagents.

The toxins are amorphous, nitrogenous substances, apparently incapable of forming crystalline compounds, yet they are dialyzable. They are insoluble in ether and alcohol, and from an aqueous solution they are precipitated by alcohol and by saturation with certain neutral salts. They readily undergo decomposition in the presence of acids and alkalies. Many are destroyed at a temperature far below 100° C., and even exposure to light may exert a destructive influence. If, there-

fore, by the process above mentioned, a poisonous principle is isolated, containing nitrogen and possessing the above-mentioned properties, it must be assumed to be or to contain a 'toxin.'

Tyrotoxicon, the poisonous principle first obtained by Vaughan from cheese, and since obtained from milk, ice-cream, &c., is not a true toxin but a diazo-benzene compound of very unstable character. Vaughan states that it may disappear in twenty-four hours from a sample of milk rich in the poison if it is allowed to stand in an open beaker. It is decomposed in water at a temperature of 90° C., and at ordinary temperatures sulphuretted hydrogen reduces it, and acids decompose it into phenol and nitrogen. It may be formed artificially by the action of nitrous acid on aniline salts. Its most stable and characteristic compound is formed by the action of potassium hydrate on the nitrate—

$$C_6H_5N_2O \,.\, NO_2 + 2KOH = C_6H_5N_2OK + KNO_3 + H_2O.$$

This compound crystallizes readily in colourless, pearly, six-sided plates or prisms. These are insoluble in ether, but soluble in water, and the aqueous solution gives a white precipitate with silver nitrate. Acetic acid decomposes it into phenol and nitrogen, the phenol being recognized by the bromine and other tests. With a mixture of sulphuric acid and phenol in equal parts it gives a green colour. It does not decompose at a temperature below 130° C.

Vaughan's process for the detection of tyrotoxicon in milk is as follows:—The acidified milk is filtered and neutralized with sodium carbonate, agitated with an equal volume of ether, allowed to stand in a stoppered cylinder for twenty-four hours, the ether removed, and permitted to evaporate spontaneously in an open dish. The aqueous residue is acidified with nitric acid, then heated with an equal volume of a saturated solution of potassium hydrate, and the whole concentrated on the water-bath. On being heated the mixture becomes yellowish brown and emits a peculiar aromatic odour. On cooling the tyrotoxicon

compound forms beautiful six-sided plates, and these are found along with prisms of potassium nitrate.

In applying the sulphuric acid and phenol test the green colour will not be obtained unless the pure crystals are used; with the impure crystals obtained as above an orange-red colour is produced. The ether residue may be used for this test. Vaughan states that the physiological test should always be applied, as certain of the tyrotoxicon reactions may be obtained from cheese and milk which are not poisonous.

The detection of the bacteria to which the poisoning may be attributed is in all cases a very difficult matter, and one which cannot be undertaken with any prospect of success by any but expert bacteriologists, with a well-equipped laboratory, and who have a licence to experiment upon animals. Each investigation is in fact an original research, and may at any stage require some original method of treatment. The recent observations of Durham [1] and Morgan [2] seem, however, to indicate that the specific organisms are in most cases members of the group which includes the B. typhosus, B. enteritidis of Gärtner, B. coli, and the paratyphoid bacilli, all of which are usually associated with excremental matter, and Durham thinks that the B. enteritidis surpasses all others in importance, since it has been found more frequently than any other bacillus in the cases of food-poisoning recently investigated.

In conducting such an investigation the earlier it is commenced the more likely it is to be successful, since the pathogenic bacteria may possibly not survive for any lengthened period when once the organisms of putrefaction begin to multiply. For the examination it is not only desirable to have specimens of the implicated food, but in case of the death of a patient small portions of the kidney, liver, spleen and heart blood should be secured if possible. Durham suggests that, where the usual swabs and serum tubes used for diphtheria

[1] 'Outbreaks due to Meat Poisoning,' *British Medical Journal*, December 17, 1898.

[2] 'The Micro-organisms of Meat Poisoning,' *British Medical Journal*, June 10, 1905.

cultivations are at hand, 'cultures should be made from the liver, spleen, kidney, and heart blood (after searing the surface of the organs with a red-hot poker) within ten or twelve hours of death, earlier if possible,' and that 'small portions of the organs—not more than one-quarter inch thick—should be put into rectified spirit for microscopic examination.' He recommends also that the spleen, kidney, and a piece of liver should be cut out with proper precautions, placed at once in separate cloths wetted with 0·2 per cent. mercuric chloride solution, each separately folded in gutta-percha tissue, and each placed in a tin (tobacco tins). The tins are then to be packed in ice and salt and at once despatched to the laboratory. Samples of the food wrapped in tissue and packed in tins should be sent at the same time in the case containing the freezing mixture.

It would be advisable to make cultures from the blood, from the organs above mentioned, and from the food on a number of plates containing Drigalski's nutrose-litmus-lactose-neutral-red medium at the earliest possible moment. This medium would enable the operator without loss of time to single out the colonies bearing a resemblance to those produced by the Gärtner, typhoid, or colon bacillus for further examination.

PART V

CHAPTER XXVII

DETECTION AND ESTIMATION OF PRESERVATIVES

Boric Acid

Qualitative Tests.—It is always desirable to perform a preliminary experiment to ascertain whether boron compounds are present or not, before making a quantitative examination, and there are two tests which are generally applicable, and which, if properly performed, are reliable: namely, the production of a green-coloured flame in burning alcohol, and the characteristic reaction of boric acid with turmeric paper. The latter is far more delicate than the former.

The Flame Test.—The ash of the material, prepared as described in the first quantitative test, is rendered strongly acid with a little sulphuric acid and hydrochloric acid (the two acids together render the test more delicate than either alone), and placed in a test tube with a little alcohol. The mouth of the tube is plugged with a rubber stopper through which passes a short piece of narrow tubing. The liquid is then boiled and the escaping alcohol vapour ignited. The production of a green flame indicates the presence of boric acid. Greater delicacy is attained if the experiment is conducted in a nearly dark room.

Turmeric Test.—The ash or extractive (free from fat) is acidulated with a little dilute hydrochloric acid, and a strip of turmeric paper is immersed therein and warmed for a few minutes. The paper is then removed, pressed between sheets of blotting-paper, and dried at a low temperature. If boric

acid is present the paper will assume a characteristic red colour, changing to blue-green after moistening with an alkali. The presence of 0·01 per cent. of boric acid in the liquid may be detected by this method.

Quantitative Tests.—If the amount of boric acid present is likely to be small, one of the following colorimetric tests should be employed for its estimation; but if fairly abundant, a volumetric process will give more reliable results.

(*a*) *Colorimetric Methods of Determination: Hebebrand's Process.*[1]—Especially applicable for fruits, fruit juices, &c., containing minute quantities of boric acid or borates.

Twenty-five to 30 grammes of the liquid is mixed with 5 c.c. of a 10 per cent. solution of calcium acetate (or calcium chloride), evaporated to dryness, and the residue ignited until free from carbon. The ash is dissolved in the smallest possible quantity of hydrochloric acid, diluted with a little water, and made faintly alkaline to litmus by the addition of a dilute solution of caustic soda. The mixture is boiled, and the precipitate filtered out and washed. The filtrate is evaporated to dryness, the residue treated first with 5 c.c. of dilute hydrochloric acid, and afterwards with 15 c.c. of absolute alcohol, and to this 15 c.c. of dilute hydrochloric acid is added, and the mixture cooled. This contains practically all the boric acid in the liquid taken, free from iron, phosphates and other possibly interfering substances, and upon the addition of 0·2 c.c. of a turmeric solution (1 gramme to 1 litre of 50 per cent. alcohol) a colour is developed, the depth of which corresponds approximately to the amount of boric acid present. The tint produced is compared with similar acid solutions containing known quantities of boric acid.

Cassal and Gerran's Method.[2]—When a solution containing boric acid is evaporated to dryness with a little turmeric solution and oxalic acid a magenta colour is produced, and upon this reaction the method to be described is based, the depth of the colour varying approximately with the amount of boric acid present. Fifteen to 20 grammes of the milk, fruit juice,

[1] *The Analyst*, vol. xxviii. p. 37. [2] *Ibid.*, vol. xxviii. p. 36.

or other liquid to be examined is rendered alkaline with barium hydrate, evaporated to dryness in a platinum basin on a paraffin bath at 105° C., the residue charred, acidified with hydrochloric acid, extracted with hot water (70 to 80 c.c.), and the solution filtered. The filter paper and contents are rendered alkaline with barium hydrate, ignited and extracted with acidified water, and the filtrate added to that obtained from the carbonaceous residue and made up to 100 c.c. An aliquot portion of this, one-tenth, is added to 10 to 15 grammes of clean white sand in a porcelain basin, the mixture made alkaline with baryta water, and evaporated to dryness on the paraffin bath. The sand is then rendered acid with a few drops of very dilute hydrochloric acid, 2 c.c. of a saturated solution of oxalic acid and 2 c.c. of a solution of turmeric (0·1 per cent.) are added, and the mixture again evaporated to dryness.

To collect the small amount of boric acid which may be lost during the evaporation, the basin is covered with a funnel connected with a series of potash bulbs containing a few cubic centimetres of baryta water, and air is aspirated until the sand is dry. The colouring matter in the sand is finally extracted with alcohol and the solution filtered. The liquid in the potash bulbs is then neutralized, and the colouring matter extracted with alcohol, and mixed with that previously obtained. The liquid is diluted in a tube to a definite volume, say 25 c.c., and compared with that obtained from standards containing known quantities of boric acid. This method is probably more delicate than that of Hebebrand, but it is very tedious, and not likely therefore to take the place of the latter or the more simple volumetric process next to be described.

(*b*) *Volumetric Methods of estimating Boric Acid.*—The only volumetric methods which are generally applicable are based upon that devised by R. J. Thomson, in which the solution containing boracic acid is made neutral to methyl-orange, a quantity of glycerine added, and the liquid titrated with standard soda solution, phenol-phthalein being used as the indicator. On the addition of the glycerine the liquid becomes

acid, the amount of acid liberated corresponding to that of the boric acid present; hence, using a decinormal solution of soda, 1 c.c. will represent 3·5 mlgm. of B_2O_3, 6·2 mlgm. of H_3BO_3, or 9·55 mlgm. of crystallized borax, $Na_2B_4O_7 + 10H_2O$. The presence of phosphates vitiates the results, since the di-hydric phosphates are neutral to methyl-orange but acid to phenol-phthalein. The glycerine used should give a pink colour with phenol-phthalein upon the addition of a single drop of the decinormal soda solution; if more than this is required the necessary correction must be made.

Estimation of Boric Acid in Butter.—Thomson's method as modified by Richmond and Harrison can be applied to butter. The percentage of water in the butter having been determined, weigh about 25 grammes of the butter into a 100 c.c. stoppered cylinder, and add sufficient distilled water to make with the water already present a number of cubic centimetres equal to the weight of butter in grammes. Then pour in 10 to 15 c.c. of chloroform, warm to melt and dissolve the butter, agitate and set aside to separate. Remove with a pipette an aliquot part of the aqueous liquid, render alkaline, evaporate to dryness and ignite. Treat the ash with hot water until all soluble matter is removed, make neutral to methyl-orange, boil to expel CO_2, add about 10 c.c. of glycerol and titrate, using phenol-phthalein as the indicator. Each c.c. of the aqueous solution corresponds to 1 gramme of the original butter, hence the percentage of the boric acid is easily calculated.

A simpler method has been devised by Richmond and Harrison which dispenses with the evaporation and ignition of the residue, &c., the time required for an estimation being thereby considerably shortened. It is carried out as follows:

Weigh out 25 grammes of the butter in a beaker, add 25 c.c. of a solution containing 6 grammes of milk-sugar and 4 c.c. N. sulphuric acid in 100 c.c. Place in the water-oven until the fat is just melted, and stir well; allow the aqueous portion to settle for a few minutes, and draw off 20 c.c.; add a few drops of phenol-phthalein solution, bring to the boil, and titrate with

seminormal soda solution till a faint pink colour just appears; add 12 c.c. of glycerol, and titrate till the pink colour is restored. The difference between the two titrations, less the amount of alkali required by the 12 c.c. of glycerol, multiplied by 0·0368, will give the amount of boracic acid in 20 c.c., and this multiplied by

$$\frac{100 + \text{p.c. of water in the butter}}{20}$$

will give the percentage in the butter examined. If the percentage of water is about the average, it may be taken as 13 without appreciable error.

It will be observed that in this process methyl-orange is not used, and that the factor employed, 0·0368, is higher than is required by theory, 0·031, for seminormal alkali. The authors found that using phenol-phthalein only, the presence of a small quantity of phosphates could be ignored, that titrating in a boiling solution in the presence of milk-sugar, the end reaction is more sharply defined, and that the difference between the two titrations constantly indicates 84·4 per cent. of the total boric acid, hence the factor

$$0{\cdot}0368 = \frac{0{\cdot}031 \times 100}{84{\cdot}4}$$

The above process is rapidly conducted, and sufficiently accurate for all practical purposes.

Estimation of Boric Acid in Milk.—Take 100 c.c. of the milk in a long-necked flask, heat rapidly to the boiling point, remove the flame, and add 8 c.c. of 2 per cent. nitric acid. Lightly stopper the flask and set aside until cool. When cold, filter off 50 c.c. (the 8 c.c. of acid added corresponds approximately to the volume of the curd produced, therefore 50 c.c. of the liquid removed will correspond to 50 c.c. of the original milk). Add a few drops of a 10 per cent. solution of calcium chloride, and render faintly alkaline by the addition of sodium carbonate. Evaporate to dryness in a platinum dish and incinerate at a moderate temperature. Exhaust the ash with successive small

quantities of boiling water and evaporate, if necessary, to 25 c.c. When cold, render neutral to methyl-orange, add 25 c.c. of glycerine, and titrate with $\frac{n}{10}$ solution of soda until alkaline to phenol-phthalein.

This process is based upon one recommended by Konerigh,[1] and gives very satisfactory results. The addition of the nitric acid removes the casein and fat, and the nitrate in the residue facilitates greatly the process of incineration.

Estimation of Boric Acid in Cream.—Weigh out 20 grammes of the cream, dilute with 80 c.c. of water in a long-necked flask, and proceed exactly as described when examining milk. The 8 c.c. of acid introduced corresponds with sufficient accuracy to the volume of the fat and curd, so that the boric acid found in 50 c.c. of the filtrate represents the amount in 10 grammes of the cream.

Estimation of Boric Acid in Cider, Fruits, &c.—It must be remembered that traces of boric acid are found in apples, pears, quinces, grapes, pomegranates, peaches, gooseberries, cherries, oranges, lemons (also in hops, radishes, and lettuce), and therefore may be detected in both foreign and British wines, in cider, perry, &c. The largest amount found in any of these substances appears to be 16 mlgm. of boric acid in 100 grammes (0·016 per cent.), and unless the quantity present considerably exceeds this it would be unwise to assert that it had been added as a preservative.

The following process for the determination of the boric acid in fruit and fruit juices was described by Allen and Tankard.[2] At the same time a process based on the volatility of methyl-borate was given, but as it is more tedious and not more accurate than the one recommended, it is not likely to be used for practical purposes.

One hundred c.c. of the cider, fruit juice, or other liquid is evaporated to dryness with a few c.c. of a 10 per cent. solution of calcium chloride. The dry residue is well charred, boiled

[1] *The Analyst*, vol. xxiv. p. 144. [2] *Year Book of Pharmacy*, 1904.

with 150 c.c. of distilled water, and the liquid filtered. The carbonaceous mass is thoroughly incinerated at a moderate temperature, and when cold boiled with a further quantity of 150 c.c. of water, and allowed to stand in the cold for some hours, or preferably overnight. The liquid is then filtered cold, and the filtrate added to the fruit extract. Although this filtrate usually exhausts the residue, the authors recommend that it should be treated a third time with water, and that this third extract should be titrated separately. The mixed aqueous extracts are next evaporated to about 30 c.c., and after cooling neutralized by decinormal acid, using methyl-orange as the indicator. As the borate exists in this solution as a calcium salt, which is only of moderate solubility, care must be taken to see that all the borate is in the solution before the titration is commenced. An equal volume of glycerine is next added, and the liquid titrated with phenol-phthalein and $\frac{n}{20}$ caustic soda solution (free from carbonate). About 10 c.c. more glycerine should now be added, when, if the titration is complete, the red colouration will remain. The glycerine used should be previously tested to prove that it is neutral to the indicator. The process gives good results when the amount of boric acid present in the sample taken is not less than 0·005 gramme.

This process can be adopted for the examination of jams and many kinds of preserved foods, using an aqueous extract of the material of known strength. Meat, sausage, &c., after being finely minced can be exhausted by macerating with lukewarm water, rendered faintly alkaline, and the filtrate concentrated and treated as above described.

Sulphurous Acid and Sulphites

Qualitative Tests.—One or more of the following tests should be applied according to the character of the solution under examination.

1. To the acidified solution add a little starch paste and a drop of a very dilute solution of iodine. If a blue colour develops sulphurous acid is either absent, or present in exceedingly small amount, but the non-appearance of a blue colour is no proof of the presence of a sulphite.

2. To the acidified solution in a long test-tube add a few fragments of pure zinc. Cover the mouth of the tube with a piece of filter paper moistened with solution of subacetate of lead and warm. The nascent hydrogen reduces the sulphite, and sulphuretted hydrogen is evolved, producing a black stain on the paper cap more or less quickly according to the amount present.

3. Mix the liquid with an equal volume of pure hydrochloric acid, add a small piece of clean, bright copper foil, and boil for a few minutes. In the presence of sulphites the copper becomes coated with a dead-black film of sulphide.

4. Acidify the liquid with phosphoric acid and distil a few c.c. The tube of the condenser should be beneath the surface of a little water in the collecting vessel. To the distillate add a few drops of bromine water and boil. In the presence of sulphurous acid, sulphuric acid will be formed, and the solution will give a precipitate with barium chloride.

Quantitative Tests.—The methods recommended by the U.S. Department of Agriculture are the following: [1]

1. Twenty-five grammes of the sample, finely divided if solid or semi-solid, is placed in a flask with about 100 c.c. of water, and 10 c.c. of normal solution of soda are added. Shake thoroughly until the whole is well mixed, and allow to stand for about fifteen minutes. Ten c.c. of 25 per cent. sulphuric acid are now added, and subsequently a little starch paste, and $\frac{n}{50}$ solution of iodine run in until a blue colour is produced. Each c.c. of the iodine solution used corresponds to 0·64 mlgm. of SO_2. This process gives fairly accurate results, except in cases when the amount of sulphurous acid or sulphite is very small: the

[1] Leach, *Food Inspector*, p. 676.

error is then one of excess, since many forms of organic matter take up small amounts of iodine.

2. Take two equal volumes of the liquid to be tested, or of an infusion of a solid or semi-solid substance, and to one add a few drops of bromine water and boil. Estimate the H_2SO_4 in both, and from the excess in the solution which has been treated with bromine calculate the corresponding SO_2.

It must be remembered that the amount of sulphurous acid found will rarely correspond with the quantity originally present in the substance under examination, since it has a tendency to undergo continuous oxidation, with the formation of sulphuric acid.

Fluoric Acid and Fluorides

Qualitative Test.—If butter is the article suspected to contain a fluorine compound, a considerable portion of it should be melted and the aqueous layer separated for the test; if fruit or jam is being examined, an infusion may be prepared. The liquid is rendered alkaline by the addition of lime water, evaporated to dryness, and ignited. One half of the residue is introduced into a platinum crucible, a little strong sulphuric acid added, and the crucible at once covered with a watch-glass, the convex surface of which has been coated with white wax, and some distinguishing mark scratched through it with a pin. The crucible is placed on a hot plate at about 80° C., and the watch-glass kept cool by filling with water. After standing an hour the watch-glass is removed, the wax melted, and the glass examined to ascertain if the distinguishing mark has been etched thereon. With as little as 1 mlgm. of a fluoride the etching will be distinct. Fluoborates and fluosilicates may be present even if the action on glass is not obtained. To detect these take the remainder of the incinerated residue, and exhaust with dilute acetic acid, filter off the insoluble portion, dry, ignite, and again treat with dilute acetic acid. The acid liquid will contain calcium borate if a

fluoborate was present, and it should, therefore, be tested for boric acid. The residue will contain calcium fluoride and calcium silicate if a fluosilicate was present in the original substance under examination. Treat the residue with strong sulphuric acid as above directed.

A positive reaction at this stage, following a negative reaction when the test was applied directly to the incinerated residue, indicates the presence of a fluoborate or fluosilicate. If boric acid was detected in the acetic solution the compound present was a fluoborate; if this acid was not detected, probably a fluosilicate was present. To confirm this a special examination must be made. The incinerated residue obtained as above is exhausted with dilute acetic acid, and, after ignition, placed in a small test-tube with a little concentrated sulphuric acid, and kept at a temperature of about 100° C. for an hour. Fluosilicic acid will be found if a fluosilicate was originally present, a gas which forms dense fumes in moist air. If the test-tube is connected with a small U-tube containing a bubble of water, the separated silicic acid will deposit on the side of the tube, impairing its transparency, and flakes of gelatinous silica may be observed in the water.

Quantitative Estimation.—No accurate process for estimating small quantities of these fluoric compounds is known. Hehner weighed the ignited ash obtained as above described from a given quantity of material after treatment with dilute acetic acid, and again after treatment with strong sulphuric acid and ignition, the fluoride thus being converted into sulphate. As 78 parts of CaF_2 correspond to 136 parts of $CaSO_4$, the amount of fluorine can be calculated. Hehner, however, found that there was a slight increase of weight in the absence of fluorides, and this amount was deducted from the total increase before making the calculation.

Probably the following method would give more reliable results. Fuse the ash of the substance under examination with four times its weight of sodium carbonate, exhaust the smelt with water, and remove the silica by digestion with a

solution of ammonium carbonate. Filter, and nearly neutralize with hydrochloric acid, add a little calcium chloride, and evaporate to dryness. Ignite gently, wash with water, dry, ignite, and weigh. Moisten with strong sulphuric acid, again ignite, weigh. The increase in weight multiplied by ·688 gives the amount of fluorine originally present:

$$CaF_2 + H_2SO_4 = CaSO_4 + 2HF$$

Formaldehyde

Detection in Milk.—The simplest test is one first suggested by Hehner. To about 3 c.c. of the milk placed in a test-tube add an equal volume of water, then introduce carefully at the bottom of the tube, by means of a pipette, 1 c.c. of strong sulphuric acid in such a way as to allow the dilute milk to float on the surface of the acid. Set aside for a time. If formaldehyde is present, a *violet* ring will form at the junction of the two fluids.

An acid containing a trace of iron acts better than pure sulphuric acid. This can be prepared by adding a drop or two of a solution of ferric chloride to about 100 c.c. of the strong acid.

The test will detect 1 part of formaldehyde in 100,000. Luebert's modification of this test is said to give a reaction with 1 in 250,000. About 5 grammes of coarsely ground crystals of potassium sulphate are placed at the bottom of a 100 c.c. flask, and 5 c.c. of milk mixed therewith. About 10 c.c. of strong sulphuric acid are then delivered slowly from a pipette down the side of the flask. After standing a few minutes the salt becomes of a violet colour. If there is no formaldehyde present, a brown colour only is developed, ultimately becoming black.

The Phloroglucol or Jorissen's Test.—This depends upon the production of a salmon colour when phloroglucol and a caustic alkali are added to a solution containing formaldehyde.

To 25 c.c. of the milk in a flask or test-tube, 10 c.c. of a 0·1 per cent. solution of phloroglucol are added, and the mixture shaken. To this is added 10 c.c. of a 5 per cent. solution of sodium or potassium hydrate. After agitating, the characteristic colour more or less quickly appears if formalin is present even to the extent of 1 part in 100,000.

The alkali may produce a yellowish tint if the milk has been boiled, or if it contains added colouring matter, but such a tint is quite distinct from that produced by formaldehyde.

In our experience it is preferable to use the following modification of this test. Raise 100 c.c. of the milk to the boiling point, add a few drops of 25 per cent. sulphuric acid, and agitate gently so as to get as complete a separation of the curd as possible; cool quickly and strain through linen. A portion of the liquid, which is now only slightly opalescent, is used for the phloroglucol test, another portion can be tested with alkali only for comparative purposes, and the remainder may be used for the following test.

Schiff's Test.—To 25 c.c. of the strained fluid add a few drops of Schiff's reagent (a solution of magenta decolourized with sulphurous acid). In the presence of formaldehyde a magenta colour appears more or less quickly according to the amount of the aldehyde present. This test cannot be applied to milk direct, since the latter contains some body which gives the formaldehyde reaction. Whatever the nature of this substance may be, it is removed in the curd.

Dr. Tebb, Public Analyst to the Borough of Southwark, has made a detailed study of the use of Schiff's reagent for the detection of formaldehyde in milk, and the following are the details of the process he has devised:

'*To Precipitate the Casein and Fat from Milk.*—Fifty cubic centimetres of the sample are measured out into a tall cylindrical glass of 250 c.c. capacity, the glass is filled up to the 250 c.c. mark with water, the milk and water are well mixed together, and 0·4 c.c. of a 25 per cent. solution of sulphuric acid is added. The mixture is well agitated with a glass rod for a

minute or so. The casein and fat will then separate as a coarse precipitate, leaving a more or less clear liquid at the top. The precipitate is allowed to settle for about five minutes and the liquid filtered. In the majority of samples the filtrate will come through quite clear, but occasionally it will be opalescent or even milky; when this happens the remainder of the 250 c.c. should be poured on to the filter, and it will be found that after about 100 c.c. have gone through, the filtrate will become quite clear; this is owing to the precipitate itself lining the inside of the filter and increasing the filtering power of the paper.

Preparation of the Schiff's Reagent.—One gramme of ordinary crystalline fuchsine (*not* the acid fuchsine) is weighed out and placed in a 50 c.c. flask, which is filled up to the mark on the neck with a cold *saturated* solution of sulphurous acid in water. The sulphurous acid solution may be conveniently prepared by means of a syphon of the compressed gas. After standing for several hours the fuchsine loses its colour and goes into solution, the liquid assuming a light yellow tint. Then dilute the 50 c.c. to 1 litre with distilled water, and proceed as follows: Two Nessler glasses are taken, to one of them is added 0·5 c.c. of a 1 in 1,000 dilution of formalin, and both glasses are filled up to the 50 c.c. mark with water; then 5 c.c. of the Schiff's reagent are added to each glass, which is stirred and allowed to stand for ten minutes. It will be found that both solutions show a marked pink colour—that is to say, that at this stage the simple dilution of the reagent with water will give a similar reaction to the formaldehyde. To make the Schiff's reagent sensitive, sulphurous acid gas is bubbled in from the syphon for about ten seconds at a time until a point is reached when it will react in the Nessler glass containing formalin, but not with the plain water after standing for ten minutes. If the reagent is too strongly impregnated with sulphurous acid it will cease to react to the formalin, and hence the care required in conducting these operations. 250 c.c. of the Schiff's reagent prepared as

above (0·1 per cent. fuchsine) will be made sensitive by bubbling in the gas at a medium rate for about thirty or forty seconds.

'*Application of Test.*—Fifty c.c. of the clear filtrate from the sample of milk are poured into a Nessler glass, 5 c.c. of the Schiff's reagent added, and the mixture is allowed to stand for ten minutes. In estimating small traces of formaldehyde, which may readily be done if the Schiff's reagent is sufficiently sensitive, it is advisable to allow the liquid to stand for a longer period—that is to say, for half an hour or even an hour. To estimate the exact percentage of formaldehyde a number of standards must be prepared of known amounts of formalin added to milk. Each standard is treated by precipitation, filtration, &c., in precisely the same manner as the sample. The Schiff's reagent is then added, and the colour of the sample in the Nessler glass is matched with the nearest standard. If the Schiff's reagent is already prepared, the whole analysis, including the precipitation, filtration, &c., of six or eight standards can easily be completed within the hour.'

From experiments made to ascertain for how long after the addition of the formalin it is possible to detect it in the milk, Tebb found that this depended on the amount added. With 0·004 per cent. a considerable portion was present at the end of fifty-three hours, whilst with 0·001 per cent. all had disappeared by the following day.

It is impossible to obtain the whole of the formaldehyde introduced into a sample of milk by distillation either of the milk alone, or after the addition of a little sulphuric acid, but apparently one-third of the total quantity present passes over in the first 20 c.c. distilled from 100 c.c. of milk. The tests above described can be applied to this distillate, but it seems to us to be preferable to use the whey, and to examine the sample as quickly as possible after collection.

The following test suggested by Hehner may be applied to such a distillate. To about 20 c.c. of the distilled fluid add one drop of a 5 per cent. solution of phenol, and pour carefully

into a test-tube containing a little strong sulphuric acid. A crimson colour is produced at the plane of contact of the two fluids if formaldehyde be present. The colour appears in a very short time with 1 part of formaldehyde in 100,000, and instantly with a little stronger solution. The limit appears to be 1 in 200,000.

Formaldehyde being a reducing agent, its presence can also be confirmed in the distillate by adding thereto a few drops of a solution of ammonio-nitrate of silver and setting the tube aside, in the dark, for twenty-four hours. The distillate from a pure milk may give a faint brown colour, but in the presence of any appreciable quantity of formaldehyde the liquid becomes black. The reaction can be obtained in the distillate (20 c.c.) from milk (100 c.c.) containing 1 part of the preservative in 250,000.

As milk requires about 1 part of pure formaldehyde (2½ parts of the 40 per cent. commercial solution) to 10,000 in order to keep it fresh for three days, it is obvious that all the above tests should give very distinct reactions with milk to which sufficient preservative has been added to prevent rapid change. Unfortunately, however, as already stated, the aldehyde is gradually decomposed, and after some days it almost, if not entirely, disappears; hence the amount present in a sample may not at all represent that originally introduced. The tests, therefore, should be applied as soon after the milk is received as possible. The decomposition proceeds more rapidly if the formaldehyde is added to milk already tending to become sour.

All the tests described have applied to milk simply because formalin is the most common preservative used for this commodity, and it is comparatively rarely found in other articles of food or drink. From most other articles the formaldehyde may be obtained by distillation, and the various tests applied to the distillate.

Volumetric Estimation of Formaldehyde

The simplest and, in our experience, the most accurate process for estimating small quantities of formaldehyde is the following. It is based on that devised by Seyewetz and Gibello,[1] and takes advantage of the well-known reaction of aldehydes with bisulphites. When formaldehyde is added to a strong solution of sodium sulphite, the latter is in part decomposed, with the formation of the compound of aldehyde and bisulphite and liberation of sodium hydrate. The amount of the latter can easily be determined, and, as the following equation shows, 1 c.c. of $\frac{n}{10}$ sulphuric acid corresponds to 3·0 mlgm. of formaldehyde:

$$2Na_2SO_3 + H_2SO_4 + 2H.COH = 2NaHSO_3.H.COH + Na_2SO_4.$$

The reagents required are: (*a*) a 20 per cent. solution of sodium sulphite, to which a very small quantity of phenol-phthalein has been added, and sufficient dilute sulphuric acid to just discharge the colour; (*b*) a decinormal solution of sulphuric acid. The process is conducted as follows: Take 20 c.c. of the sulphite solution, add thereto the solution of formalin, obtained by distillation from the substance under examination, and allow to stand for two or three minutes. A pink colour appears, and the volumetric solution of acid is now run in carefully until this colour is entirely discharged. As each c.c. of acid used corresponds to 3 mlgm. of formic aldehyde, the quantity in the liquid is readily calculated.

The following experiments were made to ascertain the reliability of the method:

A solution of formaldehyde (Schering), guaranteed to contain 40 per cent., was employed and diluted to correspond to 0·1 per cent. This dilute solution was added to the neutralized sodium sulphite in varying quantities, and the titration effected.

[1] *Chemical News*, March 25, 1905

Quantity of formaldehyde taken (calculated)	Quantity of formaldehyde found
10·0 mlgm.	10·5 mlgm.
10·0 "	10·5 "
7·0 "	7·5 "
5·0 "	5·1 "
2·0 "	1·9 "

Using a 1 per cent. solution of formaldehyde the following results were obtained:

Quantity of formaldehyde taken (calculated)	Quantity of formaldehyde found
20 mlgm.	21·0 mlgm.
50 "	52·5 "
100 "	106 "

It is almost certain that the strong solution used contained over 40 per cent. of formaldehyde, as the mean of the three last determinations corresponds to 42·1 per cent. Such being the case, the results for the very small quantities are exceedingly close. In any case they are very concordant, and better than we have obtained by any other process.

Abrastol or Asaprol

This substance may be detected, according to Leffmann,[1] by the following process. If milk is being examined, take 10 c.c. and treat with 0·5 c.c. of a solution of mercuric nitrate (prepared by dissolving mercury in twice its weight of nitric acid and diluting with five times the quantity of water). If abrastol is present a yellow colouration is quickly shown. A control experiment with pure milk should be made at the same time. In wines, &c., the preservative may be detected by acidifying with a few drops of dilute sulphuric acid and shaking with an equal volume of ether or chloroform. The ether or chloroform solution is drawn off, a few drops of the mercuric nitrate solution added, and the liquids shaken. Abrastol is

[1] *The Analyst*, p. 21, January 1906.

indicated by the mercury solution turning yellow, and finally to bright red. If a fat is being examined it should be melted and the abrastol removed by shaking with 20 per cent. alcohol. The alcohol can then be distilled off and the mercuric nitrate applied to the residual aqueous solution.

Salicylic Acid

In comparatively few instances can tests be applied directly to articles of drink or infusions of food-stuffs for the detection of this acid, since so many substances interfere with the reactions, either masking them or preventing such as are characteristic. For this reason it is always advisable to attempt the separation of the acid in order to apply the tests to the acid itself or to solutions of neutral salicylates. Advantage is taken of the fact that the acid is but slightly soluble in cold water (1 in 550), whereas it is exceedingly soluble in ether (1 in 2) and in a mixture of ether and petroleum spirit. It melts between 156° to 157° C., and volatilizes completely below 200° C. It slowly volatilizes at a much lower temperature, hence its amount cannot be accurately determined by drying and weighing. It is rarely present, however, in articles of food or drink in such quantities as to render a gravimetric or volumetric estimation practicable, but fortunately there is little difficulty in estimating small quantities colorimetrically providing the pure acid is isolated. The reaction utilized for this purpose is the production of an intense purple-violet colour on the addition of a little ferric salt to a dilute solution, and it is very characteristic in the absence of other colour-producing bodies. This test, if properly applied, will detect 1 part of salicylic acid in 300,000.

If the fluid to be tested contains no appreciable amount of any substance, such as tannin, capable of giving a colour reaction with ferric salts, the acid may usually be obtained in solution sufficiently pure for estimation by the following process :

Render the solution slightly alkaline with KHO, and

evaporate to remove any alcohol present. Acidify with dilute sulphuric acid, and extract the salicylic acid by agitating with three successive quantities of a mixture of equal parts of ether and petroleum spirit. Distil off most of the ether mixture, and shake the concentrated fluid with water rendered slightly alkaline with solution of ammonia. The watery solution should be warmed to drive off the dissolved ether, and, after evaporation nearly to dryness and redilution, the liquid may be tested qualitatively by aid of a solution of ferric chloride. If the colour produced indicates the presence of interfering substances, the solution may be acidified, extracted with the mixture of ether and petroleum ether, &c., as before. In nearly all cases the acid, if present, will be sufficiently pure for detection and estimation. In the presence of tannin the following process devised by Harry and Mummery[1] can be recommended:

Into a 300 c.c. flask introduce 50 grammes of the fluid or pulp to be examined together with a little water, and mix with 15 to 20 c.c. of a saturated solution of basic lead acetate. Add 25 c.c. of N. soda solution and afterwards 15 to 20 c.c. of strong hydrochloric acid. Dilute up to 300 c.c. and filter off 200 c.c. Acidulate with hydrochloric acid and again filter if the liquid becomes turbid. The salicylic acid is then dissolved out by means of ether (three times), the ether evaporated off, the residue dissolved in a few drops of alcohol, diluted with distilled water to 100 c.c., and the salicylic acid estimated colorimetrically with ferric chloride or iron alum. In this process the alkali added first throws down the excess of lead, then redissolves the hydroxide, the albuminoids, and the lead salicylate, whilst the lead tannate remains undissolved.

If the fluid examined contains alcohol this must be previously driven off by evaporating on the water-bath, the solution first being made slightly alkaline.

The amount of lead acetate solution and of alkali may have to be increased a little, to secure rapidity of filtration and

[1] *The Analyst*, 1905, p. 124.

solution of the minimal quantity of lead hydroxide. In most beers and wines it is merely necessary to render slightly alkaline, evaporate to remove all the alcohol, and, after acidifying, to extract with ether. When very small quantities of salicylic acid are present the evaporation may be prolonged so as to concentrate the fluid. A convenient quantity to take is 200 c.c. evaporated to 50 c.c.

Spica[1] recommends the following method for the recognition of salicylic acid and, incidentally also, of saccharin. The ether and petroleum-ether solution is divided into three portions in test-tubes and each evaporated to dryness. The residues are used for the following tests.

1. To the residue in one tube add a few drops of strong nitric acid, warm for a few seconds, dilute with water, insert a piece of grease-free wool, and raise and maintain at the boiling point for some minutes. If the residue contained salicylic acid, the nitric acid would oxidize it to picric acid, and this would stain the wool a bright yellow.

2. To the second residue add about a centigramme of quicklime in fine powder and heat until charring commences. Add a few c.c. of water, boil, and decant the solution into another tube. Acidify with hydrochloric acid and add a fragment of zinc. After standing twenty minutes, pour off the solution, and add to it a few drops of a solution of potassium nitrate and α-naphthylamine hydrochloride. If saccharin were originally present, even in very minute quantity, a carmine colour will appear in a few minutes.

3. To the third residue add a few drops of sulphuric acid and a small crystal of potassium permanganate and warm. Remove the excess of permanganate by the addition of a little oxalic acid or solution of sulphurous acid. Dilute with a few c.c. of water, and add at the bottom of the tube, by means of a pipette, a few drops of a solution of diphenylamine hydrochloride. The presence of saccharin is indicated by the formation of a blue ring at the junction of the two fluids.

[1] *The Analyst*, 1900, p. 277.

For the detection and estimation of salicylic acid in butter and milk special processes must be used, the fat present rendering the ordinary methods inapplicable.

Milk.—If the sample contains an appreciable amount of salicylic acid, the addition of a solution of ferric chloride, sufficient in amount to curdle the milk, will produce a dirty, pale-brown colour, and in the separated whey a tint of violet may be detected. The difference is very marked when compared with a genuine milk.

Pellet's method consists in treating the milk with mercuric nitrate, and extracting the salicylic acid from the filtrate by means of ether. For this purpose 200 c.c. of the milk should be diluted with an equal quantity of water, warmed to 60° C., and 1 c.c. of acetic acid added. A solution of mercuric nitrate (free from any mercurous salt) is dropped in until no further precipitate is produced. The liquid is then filtered off, rendered slightly alkaline, evaporated to about 100 c.c., acidified, and shaken with ether.

Butter.—The method adopted in the Paris Municipal Laboratory consists in exhausting 20 grammes of the butter with successive quantities of warm water to which a little sodium bicarbonate has been added. The liquid is evaporated to a small bulk, acidified with sulphuric acid, and the salicylic and other acids extracted by ether. The ether is driven off at a temperature of about 80° C., and the residue dissolved in a little water, and the salicylic acid precipitated with mercurous nitrate. The precipitate is washed, diffused through a little water, and the acid liberated by the addition of a few drops of dilute sulphuric acid. This is taken up by ether, and the ethereal solution again evaporated nearly to dryness, and treated with petroleum spirit to separate traces of the other acids. Upon evaporation of this solution, the acid is then left in a condition sufficiently pure for detection and estimation.

The results obtained by quantitative examination methods, which necessitate drying of the separated salicylic acid, must

always be a little too low; better results are obtained by colorimetric or volumetric methods.

When the amount of salicylic acid isolated amounts to several milligrammes the volumetric method may be utilized for its determination, but even this quantity may be estimated colorimetrically, providing the solution is so diluted that it contains not more than 2 mlgm. of the acid in 100 c.c. of water.

Colorimetric Method of Estimation.—In using this method certain precautions must be observed to ensure reliable results. The salicylic acid must be sufficiently pure, and the solution containing it must be free from any trace of alkalinity. The ferric salt employed should, if possible, be iron alum, as this gives a purer and deeper colour than ferric chloride. According to Harvey[1] a trace of tannin does not affect the estimation, but it is obvious that any appreciable quantity would render it impossible to attain correct results. The solutions required are (1) a 1 per cent. solution of iron alum in distilled water, and (2) a 0·1 per cent. solution of salicylic acid, also in distilled water. The solution to be tested is diluted to 50, 100 c.c., or more, according to the result obtained by a rough experiment, and to 50 c.c. in a Nessler cylinder is added 2 c.c. of the iron-alum dilution. Various solutions of the standard salicylic acid are then made until one is obtained which corresponds to that which is being examined.

Volumetric Method.—The volumetric method recommended by Fresenius and Grunhut[2] is applicable for quantities of salicylic acid from 5 mlgm. upwards, if proper precautions are observed, but unless the operator has had some experience with the process his results are likely to be unreliable. The method is based upon the following reactions:

$$C_6H_4\left\langle\begin{matrix}O\,.\,H\\CO\,.\,OH\end{matrix}\right. + 8Br = C_6H_2Br_3\,.\,OBr + 4HBr + CO_2$$

$$C_6H_2Br_3\,.\,OBr + 2KI = C_6H_2Br_3\,.\,OK + KBr + I_2$$

from which it is evident that 6 atoms of bromine (480 parts) are equivalent to 1 molecule (138 parts) of salicylic acid.

[1] *The Analyst*, 1903, p. 2. [2] *The Analyst*, 1900, p. 20.

The solutions required are:

1. A solution containing 2·5 grammes of potassium bromate and 10·0 grammes of potassium bromide in 1 litre of water.

2. A decinormal solution of sodium thiosulphate.

Upon adding a solution of salicylic acid to the acidified bromate solution the above reaction takes place, providing that the solution is not too dilute, and that a considerable excess (75 to 100 per cent.) of bromine is present, and the brominated derivative is deposited in an insoluble condition. Upon adding excess of potassium iodide, and titrating with thiosulphate, the excess of bromine can be determined, and each mlgm. of bromine removed from the solution corresponds to 2·3 mlgm. of salicylic acid. The process must be carefully performed in the following manner. The approximate amount of salicylic acid must be known, either from a rough colorimetric determination, or by weighing, and it must be dissolved in water, 10 c.c. to each mlgm. of acid.

Introduce into a flask and add 1 c.c. of the bromate solution for each 10 c.c. of the solution, and a volume of strong hydrochloric acid equal to half that of the bromate solution. After standing not less than five minutes for the reaction to take place, add an excess of potassium iodide, and titrate the liberated iodine with thiosulphate. Each c.c. of bromate solution will correspond to 1·5 c.c. of sodium thiosulphate, and each c.c. of thiosulphate represents 8 mlgm. of bromine, or 2·3 mlgm. of salicylic acid. If a represents the number of c.c. of bromate solution used, and b the number of c.c. of thiosulphate required to combine with the liberated iodine, then $(1{\cdot}5\ a-b)\times 2{\cdot}3=$ mlgm. of salicylic acid present.

The following results were obtained by this process:

Quantity of salicylic acid taken	Quantity of salicylic acid found
10·0 mlgm.	9·89 mlgm.
5·0 „	5·06 „
20·0 „	19·55 „
44·0 „	43·91 „
115·0 „	114·49 „

Benzoic Acid

Considering the marked antiseptic properties of this acid, it is singular that it is not more used. There is a probability, however, that its use is more extensive than is generally suspected. It is not so easy to detect with certainty as salicylic acid, and if a mere trace of the latter acid is present, the difficulty of discovering the presence of benzoic acid is greatly accentuated. For these reasons it is probably either not frequently sought for, or is overlooked in the presence of salicylic acid.

Its isolation is attempted in exactly the same way as already described for salicylic acid. The ether solution, on evaporation, may contain salicylic or benzoic acids, or both, and also saccharin and traces of colouring matter and acetic acid. None of these interfere with the ordinary tests for salicylic acid, but all interfere with certain of the tests for benzoic acid. Saccharin may be detected by the taste, colouring matter by the appearance, acetic acid by the odour, and salicylic acid by the ferric chloride test. If all these are absent, the residue may be dissolved in a small quantity of water to which a little solution of ammonia has been added, and the solution evaporated nearly to dryness to drive off every trace of ammonia. The residue may be slightly diluted, and a drop of solution of ferric chloride added, when in presence of a benzoate a characteristic flesh-coloured precipitate is produced. Unfortunately this is by no means a delicate test.

In Massachusetts the State Board of Health frequently reports the finding of benzoic acid in jams, ketchup, &c. In the report for 1902 it is stated that, of samples of jams and jellies examined, seven contained benzoic acid, and three salicylic acid. They point out that the ferric chloride test as usually applied is inapplicable to such products as sweet pickles, by reason of the formation of basic ferric acetate when ferric chloride is applied, and that in the case of jams the characteristic colour of the ferric benzoate is apt to be

obscured by the artificial colouring matter so often present. In such cases they recommend the following method of procedure:

'Extract the acidified sample with ether, add ammonia to the ether extract in excess, and evaporate to dryness in a large watch-glass. Fasten with clips or otherwise another watch-glass of the same size above it, thereby forming a double convex shell, a sheet of filter paper being preferably interposed between the two glasses, and heat the lower watch-glass on a small sand-bath, or over a small flame. If benzoic acid is present, crystals of the same will be sublimed on the upper watch-glass, where they may be recognized under the microscope; or they may be dissolved in dilute ammonia, the solution evaporated to dryness, the residue taken up with water, and the final solution tested by ferric chloride in the usual manner.'

Peter's Method.—In the absence of salicylic acid and saccharin, the benzoic acid may be oxidized to salicylic acid by the following process.[1]

'A portion of the residue, say 0·1 gramme, from the ether or chloroform extraction of the suspected article, is transferred to a large test-tube, and dissolved in from 5 to 8 c.c. of strong sulphuric acid. Small portions of barium peroxide are then successively added, and the tube shaken in cold water to keep the temperature down, using from 0·5 to 0·8 gramme of the peroxide in all. This should produce a permanent froth on the sulphuric acid solution. After standing for half an hour the test-tube is filled three-quarters full of water, and the mixture shaken, quickly cooled, and filtered. The filtrate is then extracted with ether-chloroform, and the extract tested in the regular manner for salicylic acid.'

Brevan's Method[2] is said to be capable of detecting the presence of a milligramme of benzoic acid in the absence of

[1] Dep. Agric., U.S.A., Bureau Chem., Bulletin 65, p. 160; Leach, *Food Inspection*, p. 674.

[2] *Annales de Chim. Analyt.*, vii. 43; *Year Book of Pharmacy*, 1902, p. 39.

interfering bodies. The ether residue is transferred to a perfectly dry test-tube and 0·5 c.c. of aniline oil, containing 0·02 gramme of rosaniline hydrochloride in 100 c.c. of oil, is added. This is boiled on a sand-bath for half an hour, the mouth of the tube being covered with a small bulb of water to condense the aniline vapour. If benzoic acid is present the original red tint of the liquid will have changed to a more or less decided violet blue. After cooling, a few drops of hydrochloric acid are added to combine with the excess of aniline, and the mixture diluted with water. In the presence of benzoic acid in the original substance an insoluble dark-blue compound is deposited, which is collected, washed free from violet colour with water, and then dissolved in alcohol. The alcohol has a marked blue colour if the original substance contained as little as 1 mlgm. of benzoic acid. In our hands this test gives better results with salicylic acid than with benzoic acid. In some experiments recently made, the presence of saccharin did not appear to interfere with the reaction. The blue colour is best obtained by passing the turbid diluted liquid through a small filter, when the blue colouring matter is left on the surface of the paper, and after washing can be dissolved in alcohol.

Meisol's Method.[1]—Render 250 c.c. of the milk alkaline with baryta water, evaporate in the water-bath to 60 c.c. and mix with sufficient plaster-of-Paris to make a paste, then continue the evaporation to dryness. Powder the residue, moisten with very dilute sulphuric acid, and exhaust with 50 per cent. alcohol. Distil off the alcohol, and evaporate the residual aqueous solution to a low bulk, acidify with sulphuric acid if necessary, and exhaust by repeated shakings with ether. On evaporation of the ether, the benzoic acid is deposited, and may be recognized by its crystalline form, volatility, action with ferric chloride, &c.

There are no methods of quantitatively estimating benzoic acid such as have been described for salicylic acid. An

[1] *Chemical News*, 1903, p. 283.

approximation may be obtained by using a larger quantity of material, and weighing the ether residue, carefully dried at as low a temperature as possible.

Formic Acid

The substance under examination must be acidified with sulphuric or phosphoric acid, and distilled. The distillate, if acid, is neutralized with ammonia, and evaporated to a low bulk. With this solution, a formate being present, ferric chloride yields a reddish coloured precipitate, becoming more marked on boiling. Ammonio-nitrate of silver yields a white precipitate, becoming black on boiling, and mercurous nitrate yields a white precipitate, which quickly becomes grey from reduction to metallic mercury. Dilute solutions may give no precipitate with the silver salt, but deposit metallic silver on heating.

Quantitative Estimation.—We can find no method described for estimating small quantities of formic acid, but in our hands the following process has given excellent results. It depends upon the oxidation of the acid in the presence of an alkali by permanganate of potassium.

To the distillate containing the formic acid, concentrated if necessary, add 10 c.c. of solution of sodium hydrate (20 per cent.), raise to the boiling point, and run in from a burette a solution of permanganate (1 c.c. = 1 mlgm. O) in excess. Keep near the boiling point for fifteen minutes, more permanganate being added if necessary to keep the liquid very distinctly coloured. Allow to cool, add sulphuric acid in excess, dilute, put in a few crystals of potassium iodide, and titrate with sodium thiosulphate. The amount of permanganate added being known, the amount used up by the oxidation of the formic acid is estimated. As 16 mlgm. of oxygen will oxidize 46 mlgm. of formic acid, the quantity of the latter present is readily calculated.

$$2H.CHO_2 + O_2 = 2CO_2 + 2H_2O.$$

The following results were obtained in testing this process:

Quantity of acid taken	Quantity of acid found
3·3 mlgm.	3·8 mlgm.
6·5 "	6·4 "
13·0 "	12·6 "
19·5 "	19·0 "
32·5 "	32·6 "
65·0 "	64·7 "

If the sodium hydrate solution is not made from metallic sodium it is advisable to boil it, and add a very dilute solution of permanganate until a faint but permanent colouration is obtained. The excess of permanganate is so small that no correction is necessary. If sulphurous acid be present, this must be converted into sulphuric acid by the very careful addition of iodine solution before rendering alkaline and adding the permanganate.

Hydrogen Peroxide.—This compound when added to milk or cream, or to any substance rich in organic matter, so readily splits up into water and oxygen that it will probably never be detected in any article to which it has been added as a preservative. When hydrogen peroxide has been added to milk in a larger proportion than is necessary to 'Buddeize' it, its presence can only be detected for a few minutes after it has been added to the milk.

The most delicate test consists in the addition to 50 c.c. of the milk of 1 c.c. of 5 per cent. solution of potassium iodide, a little starch solution and 1 c.c. of dilute hydrochloric acid (1 : 6). In the presence of a minute quantity of the peroxide the blue colour appears at once. The limit of the test appears to be 1 part of H_2O_2 in 50,000 parts of fresh milk. With such a dilution the reaction can only be obtained for a few minutes after mixing. If the milk is becoming sour the hydrogen peroxide appears to be decomposed instantly, and a far larger quantity must be added to admit of detection.

Bach's reagent whilst differentiating between hydrogen

peroxide and chlorine, nitrites, and other bodies capable of liberating iodine from potassium iodide, is far less delicate than the above. The reagent consists of two solutions: (1) 0·03 gramme potassium bichromate and 5 drops of aniline oil in 1 litre of water; (2) a 5 per cent. solution of oxalic acid. To 5 c.c. of the solution to be tested an equal volume of the bichromate solution is added and 1 drop of the oxalic acid solution. Upon shaking, the production of a violet red colouration, which reaches its maximum intensity very quickly, indicates the presence of a peroxide.

Kingsett's method for determining the strength of solutions of hydrogen peroxide is as follows: Mix 10 c.c. of the solution with 40 c.c. of 25 per cent. sulphuric acid and 50 c.c. distilled water. Add 10 c.c. of this dilution to an equal volume of 10 per cent. solution of potassium iodide and allow to stand for five minutes. Titrate the iodine liberated with decinormal solution of sodium thiosulphate, and calculate the amount of hydrogen peroxide from the equation $H_2O_2 + 2HI = 2H_2O + I_2$. The thiosulphate being of the correct strength, each c.c. will represent 0·8 mlgm. of available oxygen or 1·7 mlgm. H_2O_2.

CHAPTER XXVIII

DETECTION AND ESTIMATION OF METALLIC IMPURITIES

Arsenic.—The commission of experts appointed by the Manchester Brewers' Association recommended Reinsch's test for the detection of arsenic in beer, and directed it to be performed in the following manner:

'Take 200 c.c. of the beer in a porcelain evaporating dish, acidulate with 1 c.c. of pure concentrated hydrochloric acid, and evaporate until the volume of liquid is reduced to one-half. Then add a further 15 c.c. of the hydrochloric acid, and insert a piece of pure burnished copper foil, a quarter of an inch by half an inch in size, and keep the solution gently simmering for an hour, replacing the evaporated liquor from time to time by distilled water. If at the end of an hour the copper remains bright and red, the beer is arsenic free.

'If a deposit is obtained on the copper, the foil should be removed, washed successively with water, alcohol, and ether, dried at a temperature not exceeding 100° C. and subjected to slow sublimation in a thin reduction tube, not less than 2 inches long and having an internal diameter of 0·15 inch, the upper portion of which should be warmed before the sublimation begins. For the purpose of the sublimation a small spirit lamp should be used. If any sublimate is obtained, it must be examined under a magnifying power of about 200 diameters. Any sublimate which does not show well-marked octahedral or tetrahedral crystals is not to be considered arsenical. Mere blackening of the copper, or deposit thereon, does not demonstrate the presence of arsenic.

'The addition of oxidizing agents to decompose sulphites, and the use of reducing agents to decompose possible arsenates, is not recommended, as such a procedure is in our opinion unnecessary in the testing of beer, and introduces possible sources of error.'

This test is not absolutely reliable, nor is it so delicate as the test next to be described. It will, however, detect one-

fiftieth of a grain of arsenic in the gallon of beer (1 in 3,500,000). Neither this nor Marsh's test will detect arsenic in organic combination, hence when the presence of such a compound is suspected the organic matter must be destroyed before applying tests.

A conjoint Committee of the Society of Chemical Industry and of the Society of Public Analysts, appointed in March 1901, after an examination of various methods of detecting and estimating arsenic, recommended the methods of Marsh-Berzelius, and finding great difficulty in obtaining arsenic-free chemicals, the Committee in their report described the methods they recommended for securing the requisite purity of the reagents, &c., employed. The following is a copy of their report,[1] every detail of which must be carefully followed if reliable results are to be obtained.

'*Materials required.*—Hydrochloric acid.—The purest hydrochloric acid obtainable is very rarely free from arsenic. To the "pure" acid, as purchased for analysis, diluted with distilled water to a specific gravity of 1·10, sufficient bromine is added to colour it strongly yellow (about 5 c c. per litre), sulphurous acid, either gaseous or in aqueous solution, is then added in excess, and the mixture is allowed to stand for at least twelve hours. Or hydrobromic acid and sulphurous acid may be used. The acid is then boiled till about one-fifth has evaporated, and the residue can either be used direct, or may be distilled, the whole of the arsenic having volatilized with the first portion.

'Sulphuric acid.—This is more frequently obtainable arsenic-free than hydrochloric acid. If not procurable, to about half a litre of sulphuric acid, "pure for analysis," a few grammes of sodium chloride are added and the mixture distilled from a non-tubulated glass retort, the first portion of about 50 c.c. being rejected. For the purpose of the test to be described, one volume of the distilled acid is diluted with four volumes of water.

'Nitric acid can, as a rule, be obtained free from arsenic without much difficulty, the pure redistilled acid being used. This should be tested by evaporating 20 c.c. in a porcelain dish, which should then be washed out with dilute acid, and tested as described in this report.

[1] *The Analyst*, February 1902, p. 48.

'The purified acids should be prepared as required, and should not be stored for any length of time. If this be unavoidable, however, Jena flasks are to be preferred, since most bottle-glass is liable to communicate traces of arsenic.

'Zinc.—Arsenic-free zinc is obtainable from chemical dealers. It should be regranulated by melting it and pouring it from some height into cold water.

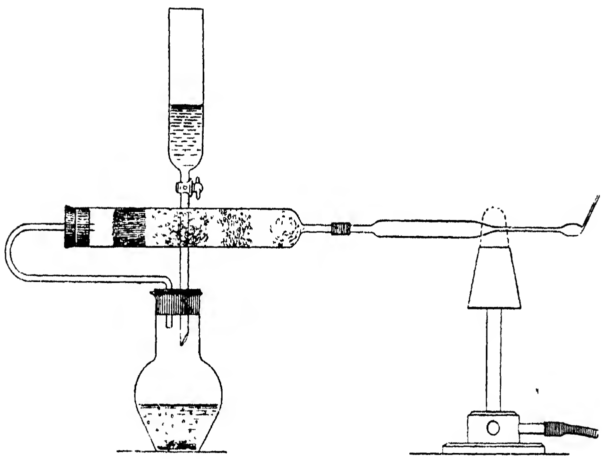
'Lime.—Caustic lime, even when made from white marble, is not always free from arsenic. A selection must, therefore, be made from various samples. If pure lime is not obtainable, magnesia may equally well be used, and can be more readily obtained of sufficient purity.

'Calcium Chloride.—This salt often contains arsenic, and before being used as a drying agent must be freed from the volatilizable part of the impurity by moistening it with strong hydrochloric acid, fusing and regranulating.

'*Apparatus.*—A bottle or flask, holding about 200 c.c. (for frothing materials preferably wider at top than bottom), is fitted with a doubly bored cork, india-rubber stopper, or with a ground-in glass connection, carrying a tapped funnel holding about 50 c.c. and an exit tube. The latter is connected with a drying tube containing, first, a roll of blotting-paper soaked in lead acetate solution and dried, or a layer of cotton-wool prepared in a similar way, then a wad of cotton-wool, then a layer of granulated calcium chloride, and finally a thick wad of cotton-wool. To this tube is fitted a hard-glass tube, drawn out as shown in the figure, and of such external diameter that at the place where the arsenic-mirror is to be expected the tube just passes through a No. 13 Birmingham wire gauge (corresponding with 0·092 inch). The exact size is not material, but all tubes used for standards and tests should be as nearly as practicable of the same diameter. A good Bunsen flame is used to heat the hard-glass tube close to the constriction. About 1 inch of tube, including the shoulder, ought to be red-hot. A piece of moderately fine copper gauze (about 1 inch square) wrapped round the portion of the tube to be heated assists in insuring equal distribution of heat. A suitable form of apparatus is shown in the figure on page 360.

'About 20 grammes of zinc are placed in the bottle, and washed with water to clean the surface, as particles of dust may contain arsenic; all parts of the apparatus are connected, and a sufficient quantity of acid (prepared, as previously described) allowed to flow from the funnel, so as to cause a fairly brisk evolution of hydrogen. When the hydrogen flame, which during the heating of the tube should be kept at as uniform a height as possible (about a quarter of

an inch), burns with a round, not pointed, tip, all air has been removed from the apparatus. The Bunsen burner should then be placed under the hard-glass tube as described, and more acid (10 to 20 c.c. is generally enough) run in as required. With good materials no trace of a mirror is obtained within half an hour. Great care must be taken that when additions of acid are made to the zinc no bubble of air is introduced, since in presence of air the arsenic mirror may become black and unevenly distributed, whilst it is brown when the experiment has been properly conducted.



'Should the blank experiment not be satisfactory it must be ascertained, by changing the materials methodically, whether the fault lies with the acid, zinc, other materials, or with the apparatus.

'*Preparation of Standard Mirrors.*—When a satisfactory blank experiment has been obtained, a series of standard mirrors must be prepared under the following conditions:

'A hydrochloric acid solution of arsenious oxide, containing in each cubic centimetre 0·001 milligramme As_4O_6, is prepared by diluting a stronger solution with distilled water. Two c.c. of this solution (equal to 0·002 milligramme of arsenious oxide) are introduced into the apparatus, a new tube having been joined to the drying tube. If the zinc is sensitive, a distinct brown mirror is obtained after twenty minutes. It is important to note that some "pure" zinc is, from a cause at present unknown,[1] not sufficiently

[1] *Vide* Chapman and Law, *The Analyst*, 1906, p. 3.

sensitive—that is to say, the addition of minute quantities of arsenic produces no mirrors. The portion of the tube containing the mirror should be sealed off while still filled with hydrogen; in contact with air the mirrors gradually fade. Mirrors are now similarly made with 0·004, 0·006, 0·008, and 0·01 milligramme of arsenious oxide. With a little patience it is easy to obtain the deposits of arsenic neatly and equally distributed. The standard mirrors, properly marked, are mounted on a white card or porcelain slip. It is to be understood that the first stage of every test must be a blank of at least twenty minutes.

'Hydrochloric acid is somewhat more sensitive than sulphuric acid—that is to say, it gives rather denser mirrors with minute quantities of arsenic. If for one reason or another sulphuric acid is preferred by the operator, he must make a set of standard mirrors with sulphuric acid, and use these for comparison. Organic materials, such as beer, yeast, &c., cannot be tested when sulphuric acid is used without destruction of the organic matter, whilst, as a rule, they can be directly tested with hydrochloric acid. However, many materials are met with in which it is preferable to destroy the organic matter.

'*Procedure without Destruction of Organic Matter.*—The apparatus is started, and a blank experiment allowed to go on for twenty minutes. If no trace of deposit is obtained, 10 c.c. of the liquid to be tested and about 10 c.c. of hydrochloric acid are put into the funnel, and slowly introduced into the bottle without air-bubbles. Some materials (beers, for example) are apt to froth, hence the necessity for slow introduction. If after about ten minutes no mirror appears, another 10 c.c. of the liquid, with 10 c.c. of hydrochloric acid, are added, and the experiment continued for fifteen to twenty minutes, acid being from time to time added as may appear necessary.

'Malt.—Fifty grammes of the malt are placed in a 300 c.c. separator funnel, furnished with a stopcock; 50 c.c. of hydrochloric acid, prepared as described, and 50 c.c. of water are warmed to about 50° C. and poured on the malt. The whole is then allowed to digest for fifteen to twenty minutes, with frequent agitation, and the acid then allowed to run off by the stopcock. About 60 c.c. of the acid liquor is thus obtained, of which every 20 c.c. contains the arsenic from 10 grammes of the malt.

'Hops.—Twenty grammes of hops are digested with 100 c.c. of dilute hydrochloric acid (one volume of the purified acid to one volume of water) at about 50° C. for half an hour, 50 c.c. of the strained-off liquid being used for the test.

'Sugar and other brewing materials are dissolved in water, 10 c.c. of acid added, and the solution tested direct, operating upon from 10 to 20 grammes of material.

'*Destruction of Organic Matter.*—(*a*) *Acid Method.*—Ten grammes of the substance are placed in a 3½-inch porcelain crucible, and covered with pure distilled nitric acid (about 10 to 15 c.c.). The whole is then heated on a sand-bath until the evolution of brown fumes ceases. Three c.c. of concentrated arsenic-free sulphuric acid are then added, and the heating continued until the mass just begins to char, when a further quantity of 5 c.c. of nitric acid is added. The heating is now continued until all the acid is expelled, leaving in the crucible a black, nearly dry, charred mass. The crucible is about half filled with water, and a few c.c. of hydrochloric acid, or of dilute sulphuric acid, run in (according as the one or the other is to be used in the Marsh apparatus), the whole being allowed to extract for about half an hour on a water-bath. It is then filtered into a porcelain basin, the charred mass washed with hot water, and the filtrate concentrated down to about 30 c.c., which is allowed to cool, and is then ready for the test. It is essential that the mass should be thoroughly charred, and that the solution when filtered should be colourless.

'In the case of beer, 10 to 20 c.c. are evaporated to dryness on a water-bath, and the residue oxidized as above stated.

'Hops.—Ten c.c. of pure nitric acid and 5 c.c. of pure concentrated sulphuric acid are mixed in a 3½-inch porcelain crucible, and the hops are then added in small portions at a time, each quantity being thoroughly disintegrated by pressure under the acid with a glass rod, a further quantity of 5 c.c. of nitric acid being added when about half the hops have thus been introduced. The crucible with its contents is then cautiously warmed so as to avoid frothing over. When the evolution of dense red fumes ceases the heating is increased, and the acids are evaporated on a sand-bath, and a dry charred mass extracted with dilute acid, filtered, concentrated, and introduced into the Marsh apparatus in the ordinary way. It may be noted that with many English hops of relatively fine texture the addition of the second quantity of nitric acid above recommended is unnecessary.

'When, owing to the presence of larger quantities of arsenic, smaller amounts of substance—e.g. 0·5 gramme to 2 grammes—are taken, the quantities of acids recommended above may, of course, be reduced.

'(*b*) *Basic Method.*—The materials are mixed with pure lime or magnesia (1 gramme for 20 c.c. of beer), dried and incinerated. For

sugars or other solid materials about half their weight of base is employed. The ash is dissolved in hydrochloric acid, and the solution tested. This method is not recommended for hops.

'Of coal or other fuel, after careful sampling, two portions of 1 gramme each are weighed. One portion is incinerated in a platinum dish in a muffle, and the hydrochloric acid extract of the ash tested for "non-volatile arsenic." The other is intimately mixed with 1 gramme of lime or magnesia and also incinerated. The hydrochloric acid extract of the latter gives the "total arsenic," the difference between the two determinations being the "volatile arsenic." It may in some cases be found that the above-mentioned quantity of fuel gives a mirror too dense to be measured. When this is the case the hydrochloric acid extract is diluted to a determinate volume and an aliquot portion taken.

'Sulphites.—The sulphurous acid must be oxidized by bromine, the excess of the latter being removed by heating.

'The Committee have convinced themselves that arsenic in both states of oxidation can be detected and estimated by the procedure described.

'As an additional precaution a fresh tube should always be substituted for that containing the mirror, and the experiment continued for a further period of fifteen minutes. Should a second mirror be formed, the quantity of arsenic with which it corresponds is to be added to that shown by the first.

'It must be understood that the tests are only approximate, and that mirrors corresponding with less than 0·003 milligramme of arsenious oxide in the quantity of materials taken cannot be safely relied upon. When a mirror has been obtained, a duplicate test should always be made to preclude error by accidental contamination.

'The proof that the mirrors are arsenical is obtained as follows: The narrow portion of the tube containing the mirror (which should not be denser that that produced by 0·01 milligramme of arsenious oxide) is cut off, the hydrogen replaced by air, and the ends sealed up. The tube, held in the tongs, is then heated by drawing it repeatedly through the flame of a Bunsen lamp until the mirror has disappeared. On cooling, minute crystals of arsenious oxide deposit, the sparkling of which can be seen with the naked eye if the tube be held before a luminous flame, and which can be readily identified under the microscope by their crystalline form.

'This test, as recommended, is one of such extreme delicacy, that with quantities of 20 grammes (or 20 c.c.) it will give an indication of the presence of 0·000015 per cent. (or 1 part in 7,000,000) of arsenious oxide.'

This process gives excellent results and leaves little to be desired. It is the one now almost universally employed. An attempt has been made to simplify it, where an electric current of sufficient intensity is available, by generating the hydrogen electrolytically, using platinum electrodes. This method is fully described in the report of the Inland Revenue Departmental Committee.[1]

We have had no experience with this electrolytic process, but Sand and Hackford regard platinum electrodes as altogether unsuitable for the purpose, and recommend lead as a substitute.[2]

The advantages claimed for the electrolytic method are:

1. That it obviates the use of zinc.

2. That it is simple in execution.

3. That the results obtained by different operators are strictly comparable.

4. That the whole of the arsenic can be obtained from a beer in thirty minutes, and beer and aqueous extract of malt may be used without prior destruction of the organic matter.

5. That the deposits obtained are more uniform in character than those furnished with the acid and zinc method.

6. That a number of estimations may be made at the same time.

The disadvantages are that the apparatus is costly, and that a current of sufficient intensity is not always available.

Gauter[3] has described a method of separating very minute quantities of arsenic based on the fact that, on precipitating iron in the ferric state from the suspected solution, every trace of arsenic in solution is simultaneously carried down. The arsenic thus removed is subsequently determined by the Marsh-Berzelius method. The test is alleged to be so delicate that 0·001 mlgm. of arsenic may be determined in a litre of water. Using this process Gauter has been able to show that arsenic is almost ubiquitous.

[1] *Report Royal Commission on Arsenical Poisoning*, vol. ii. p. 208.

[2] *Proceedings, Chemical Society*, xx. 123.

[3] *Analyst*, December, 1902, p. 367.

Many other excellent and delicate methods of detecting arsenic have been devised, but as the results would always require confirming by Marsh's test it is quite unnecessary to describe them.

Lead and Copper.—In water, and aerated waters free from saccharine matter, tests may be applied directly to the liquid for the detection of lead and for its estimation colorimetrically, but in all cases where organic matter is present the latter should be completely destroyed before proceeding to apply either qualitative or quantitative tests.

A fair sample of the whole mass having been secured, it should be evaporated as nearly to dryness as possible in a porcelain capsule upon the water-bath, moistened with strong sulphuric acid (free from lead), and carefully heated until completely carbonized. The ignition may then be continued in a muffle until all the carbon has disappeared, the process being hastened, if necessary, by occasionally moistening the residue with strong nitric acid. The ash is then moistened with acetic acid, an excess of ammonia added with a little water, and the solution boiled and filtered. The process is repeated until the ash is exhausted, and the filtrate is made up to a definite volume. Small quantities may then be tested for copper by potassium ferrocyanide; if any appreciable quantity is present the liquid will have a brown colour, if absent, lead may be detected by the addition of sulphuretted hydrogen, after acidifying with hydrochloric acid. If copper is present, a little potassium cyanide must be added to the solution before adding the sulphuretted hydrogen water to test for lead.

The amount of copper present, if very minute, can be estimated colorimetrically by means of potassium ferrocyanide; if present in appreciable quantity it may still be estimated colorimetrically by comparison with standard solutions of copper containing solution of ammonia, or it may be determined electrolytically. For this purpose a known quantity of the liquid is acidified, and placed in a tared platinum dish or crucible. This is connected to the zinc of a single Grove's

cell. A platinum spatula or slip of platinum foil is connected with the platinum of the cell and suspended in the liquid, care being taken that it does not touch the side or bottom of the dish or crucible. The current is allowed to pass for several hours, or until a drop of the liquid removed ceases to give a colouration with dilute solution of potassium ferrocyanide. The dish is then removed, washed successively with boiling distilled water, alcohol, and ether, dried and weighed. The weight of the copper in the amount of liquid used being thus ascertained, a simple calculation gives the amount in the quantity of original material employed.

In another portion the lead may be determined colorimetrically by the addition of sulphuretted hydrogen water, and comparison of the tint produced with that of solutions of lead of known strength. In the presence of copper, a little potassium cyanide must have been added prior to the introduction of the sulphuretted hydrogen.

Paul and Cownley recommend the following process for the estimation of copper in vegetables. Carbonize about 100 grammes in a platinum dish, extract the ash with strong hydrochloric acid, filter through an acid-washed filter into a porcelain dish. The residue, insoluble in acid, is moistened with a few drops of nitric acid, dried and ignited. The resulting mass is exhausted with strong hydrochloric acid filtered into the first portion in the porcelain dish, and the residue in the filter washed with hot water. The hydrochloric acid solution is then evaporated down to about 30 c.c., placed in a weighed platinum dish, the copper precipitated by pure zinc and weighed. If the deposited metal is not of a pure copper colour, it is dissolved in a little nitric acid, made up to a known quantity, and the metal estimated colorimetrically in an ammoniacal solution.

Great differences are often found in determinations made by different chemists, and Vedrödi[1] claims to have obtained a hundred times as much copper by the following method

[1] *Chem. Zeit.* May 1896, and *Pharm. Journal,* June 6, 1896.

than by Lehmann's, which consists in destroying the organic matter with sulphuric acid. He burns the material in a muffle for eight hours, exhausts the ash with hydrochloric acid, precipitates the copper as sulphide with sulphuretted hydrogen, and after ignition weighs as oxide. Dr. Paul has pointed out that it is unsafe to regard this final product as pure copper oxide.

Tin.—Proceed as directed for copper and lead to obtain the ash. Transfer this to a silver crucible and fuse with caustic soda, exhaust the smelt with boiling water acidulated with hydrochloric acid, and after filtration pass sulphuretted hydrogen into the solution. A yellow precipitate soluble in ammonium sulphide indicates the presence of tin, and the quantity may be estimated by collecting the precipitate in a small crucible and converting it into stannic oxide by the continued application of a gentle heat with free access of air, and weighing.

Antimony.—Beverages kept in bottles, the stoppers of which have rubber rings, should be examined for particles of rubber. For this purpose several bottles should be opened and the contents passed through a small filter paper. The deposit can then be examined with a magnifying glass and the pieces picked out, or the whole may, after washing, be boiled with a little concentrated nitric acid, evaporated to dryness, and the residue treated with a little hydrochloric and tartaric acid, and taken up in boiling water. The solution can then be examined by the zinc platinum test for the presence of antimony.

If the presence of an appreciable quantity is indicated, the solution must be placed in a small flask, warmed, and a current of sulphuretted hydrogen passed through it until saturated. The flask should then be stoppered and kept for a few hours in a warm place, after which the excess of sulphuretted hydrogen is removed by a current of carbon dioxide, and the precipitate collected in a small tared asbestos filtering tube. It is then dried at a gentle heat in a slow current of carbon dioxide, after which the heat is carefully increased until the sulphide turns black and all free sulphur has volatilized. The tube is then

allowed to cool, the carbon dioxide displaced by air, and the tube again weighed. The increase in weight corresponds to the amount of antimony sulphide in the material used.

Smaller quantities may probably prove capable of determination by Marsh's test, in the way described under arsenic. The antimony mirror is deposited nearer the flame than the arsenic mirror, and when heated in a current of sulphuretted hydrogen it is converted into the orange or black sulphide. If now dry hydrochloric acid is passed through the tube, chloride of antimony is formed and volatilizes.

Our experiments in order to make this test quantitative proved very unsatisfactory, and the following method was adopted. A standard solution containing tartar emetic equivalent to 0·1 mlgm. of antimony in 1 c.c. was prepared, from which further dilutions were made as required. From 1 to 10 c.c. of these dilutions was acidulated with hydrochloric acid, placed in a platinum dish, a fragment of zinc added, and the deposit formed in the course of one or two hours compared with that derived from the same quantity of the fluid to be tested prepared as above described. The limit of the test appears to be about 0·1 mlgm. of antimony. Using 10 c.c. of liquid containing 0·01 mlgm. per c.c., a decided stain was obtained, but with greater dilutions the results were negative, or the stain too faint to be recognizable with certainty. More concordant results were obtained by this method than by the Marsh-Berzelius process, and with very much less trouble and expenditure of time.

CHAPTER XXIX

EXAMINATION OF FOOD AND DRINK FOR COAL-TAR COLOURS

THE following simple tests have been found reliable in a recent investigation carried out by one of us. They are based on a method recommended by Sostegni and Carpentieri[1] for the detection of acid dyes. The great majority of coal-tar dyes used for food colouring are 'acid,' very few 'basic' colours being employed for this purpose. The basic colours are taken up by white grease-free wool upon boiling in a neutral or faintly alkaline solution, and the colour removed by the wool can be obtained in solution by treating the wool with a 5 per cent. solution of acetic acid. The acid colours are taken up by the wool from acid solutions, and can be recovered from the wool by treating the latter with a very dilute solution of ammonia. The double dyeing recommended below is necessary because certain vegetable colours, such as logwood and cochineal, are also capable of staining wool. These colours, however, are not taken up from the wool when this is subsequently treated as directed.

Make a clear solution or infusion of the substance to be examined and divide into two portions of 50 to 100 c.c. each. Render one faintly alkaline with ammonia and the other distinctly acid with hydrochloric acid. Into each put about 1 foot of white worsted which has previously been well boiled in distilled water rendered faintly alkaline with caustic soda, and afterwards washed to remove any trace of alkali. Place the flasks on a hot plate and keep the liquid at the boiling point for an hour, or less if the wool is distinctly dyed. The dyed wool is then removed, pressed between sheets of blotting-paper, and washed by boiling in two successive quantities (20 c.c.) of distilled water.

[1] *Food Inspection and Analysis*, Leach, p. 641.

The wool from the acid solution is then boiled in about 20 c.c. of dilute solution of ammonia (1 part of liq. ammon., sp. gr. 0·88, to 9 parts of water), whilst the wool from the alkaline solution is boiled in about the same quantity of 5 per cent. acetic acid. The wools are removed, and the alkaline fluid made acid by the addition of acetic acid, and the acid liquid made alkaline by the addition of ammonia. A fresh, grease-free piece of worsted, 2 or 3 inches in length, is now put into each tube, and both are placed in a water-bath for about half an hour, at the expiration of which time the wools can be removed, washed in distilled water, dried, and mounted for comparison with worsted similarly treated with known dyes.

If an aniline dye were present in the original solution one of the samples will be brilliantly dyed. If the dye present were of a 'basic' character, the wool originally inserted in the alkaline liquid will be dyed, whereas that in the acidified solution will be barely tinted. If, on the other hand, as is usually the case, the dye is of the acid type, the wool originally placed in the acidified solution will be the one most distinctly dyed. Such vegetable colouring matters as we have examined do not dye the short lengths of worsted, at the most giving them merely a dirty appearance.

Assuming that it is wished to identify the dye, this may in many cases be done by comparing the wools as above suggested, or by applying tests to them or to the colouring matter removed, from the wool first used, by the action of an acid or an alkali. Allen's Tables[1] can be consulted with advantage for this purpose.

Usually it suffices, when it has been ascertained that such a dye is present, to determine whether it contains arsenic or not. For this purpose the dye itself must be obtained and examined, or the article of food or drink submitted to the various tests for arsenic. In the latter case, however, the detection of the poison would in most cases be far from conclusive proof that it was introduced with the dye.

[1] *Commercial Organic Analysis*, vol. iii. part i.

CHAPTER XXX

DECEPTIVE APPEARANCES

Foam and Facing

A recent article in the 'Lancet,'[1] entitled 'Fraudulent Foam,' has directed attention to the fact that many beverages are made more attractive by the addition thereto of preparations which readily produce a foam upon the surface of the liquid, and it is argued that 'the practice of making things not what they seem is fraud, and nothing but fraud; and even if perfectly innocuous substances are used for the same purpose, the intention is obviously again to deceive and to produce a wretched imitation of the genuine article.' No doubt foaming preparations may be used in beers and such like liquids to conceal staleness, and give an appearance of freshness and palatableness, but they are often used merely to give permanence to an otherwise evanescent effervescence, and to produce a more pleasing appearance. For this purpose gelatinous preparations, gums, and infusions and tinctures of quillaia bark have been used for a long series of years. These are added to syrups for mixing with aerated waters, and without any idea of fraud. The quillaia bark owes its property of producing a froth to the presence of a glucoside, saponin, which undoubtedly is a poison if taken in quantity, paralyzing the respiratory and vaso-motor centres. It has been recently recommended as an expectorant, in doses of 1½ to 3 grains in the form of tincture. An exceedingly small quantity is required to produce the surface tension requisite for frothing, and it is exceedingly doubtful whether in the proportion used

[1] February 3, 1906.

it can do any possible harm. The writer in 'The Lancet,' however, urges that 'though the effect of small doses may be inappreciable, yet the presence of a poison in beverages in any quantity at all is highly objectionable.' There are many substances which, when taken in quantities, are injurious to the system, which may therefore be regarded as poisons, which are perfectly harmless when taken in smaller proportions, and although saponin preparations have been used for forty years and upwards in the preparation of beverages no suspicion has ever arisen of their producing any evil effects.

Saponin is now a generic name for a series of glucosides, or mixtures of glucosides, and other substances, obtainable from quillaia bark, root of the common pink, sarsaparilla root, &c. Kruskai in 1891 enumerated 150 varieties of saponin, and Kobert[1] has shown that these are all mixtures consisting of at least four organic substances, together with traces of inorganic bodies. The crude saponin from quillaia bark contains an acid, quillaic acid, which is slightly toxic; sapotoxin, an acrid and very poisonous principle; lactoxin, an inert carbohydrate; and saponin ($C_{13}H_{30}O_{10}$), which in a pure state is also inert. Crude saponins from different sources with the same general formula have different chemical characteristics, and differ in their degree of toxicity. They are soluble in water, slightly soluble in alcohol, and insoluble in ether, chloroform, and benzol. When a solution of saponin is injected into the blood stream the red-blood corpuscles are dissolved, but when administered per os they are much less poisonous, being difficult of absorption in the intestinal canal. They therefore do not act as blood poisons when swallowed.[2] According to Mitchel Bruce,[3] saponin is probably excreted in part by the skin and kidneys, both of which it stimulates, increasing the volume of urine and the most important solid constituents. Exceedingly small quantities may produce fatal effects in

[1] *Year Book of Pharmacy*, 1886, p. 82.
[2] Mann, *Forensic Medicine and Toxicology*, p. 414.
[3] Bruce, *Materia Medica and Therapeutics*.

animals if introduced subcutaneously, but as much as 2 grammes per kilogram of weight of the most toxic constituent is required to kill a dog when administered with food. The saponins of commerce are very variable in composition, and though capable of causing, in large doses, catarrh of the mucous membrane, it is very doubtful whether they come within the category of 'poisons.' One ounce of a 5 per cent. tincture or infusion of quillaia bark is generally added to a gallon of syrup, and about 2 ounces of this is added to 8 ounces of aërated water for making temperance beverages. Such a beverage would therefore contain about 1 part of quillaia bark in 15,000, or 1 of crude saponin in 1,500,000, an amount which it is difficult to conceive can have any deleterious effect even if such a liquid is imbibed largely and frequently. Notwithstanding this the use of saponin appears to have been interdicted in Austria.

The detection of these minute quantities of saponin in liquids such as beer and saccharine beverages would be a very difficult matter. After neutralizing, a large excess of barium hydrate should be added, and the precipitated barium compound collected, washed with a little water, and decomposed by a current of carbonic acid gas. If the filtered liquid easily froths, saponin is probably present. The solution may be evaporated to dryness and exhausted with boiling alcohol, sp. gr. 853, the alcohol filtered off, and the residue examined. It should be acrid in taste, produce froth when shaken with water, and be precipitated from its alcoholic solution by the addition of excess of benzol or ether.

Another type of deceptive appearance is that of the 'facing' of rice.[1] By attrition, suitably applied, the surface of the rice grains is made smooth and shining, the appearance being thus improved. To this method there can be no objection, but it is now becoming common to introduce oil, paraffin, French chalk, and possibly other substances, during the attrition, apparently with the view of making inferior samples more closely resemble

[1] *Lancet*, February 10, 1906.

rice of a superior quality. Messrs. Cribb & Richards,[1] who have recently examined a number of such samples, state 'that the proportion of foreign matter present in some cases is quite sufficient to constitute a fraud, inappreciable perhaps to the individual purchaser, but ample to give an unscrupulous vendor an advantage over his more honest rival.' They suggest also the possibility of the insoluble substance, chiefly used, being injurious to health, as it may possibly set up mechanical irritation in the intestines, or lead to the formation of fæcal concretions. This is a somewhat far-fetched theory, if the material used is talc or French chalk, especially with the infinitesimal amount left adherent to the rice. It is possible, however, that more objectionable substances may be used. In all cases Cribb & Richards found that by washing the rice with distilled water the liquid became opalescent, and that the insoluble matter was not taken up by hydrochloric acid, and that it contained magnesia and silica. In normal rice the ash is nearly always under ·5 per cent. and contains only a trace of matter insoluble in hydrochloric acid, and the magnesia as MgO forms only from 9 to 11 per cent. of the total ash. In the faced rice the insoluble ash almost invariably formed 40 per cent. of the total ash, and consisted mainly of magnesia and silica.

Facing with paraffin or other fat would be detected by washing the rice with petroleum ether, distilling off the ether and examining the residue.

When such faced rice is washed before being used, as all rice should be, no possible harm can result from the facing. The process doubtless enables an inferior article to be classed as a superior one, and to this extent is fraudulent, but from the public health point of view the matter is scarcely one of importance so long as the 'facing' is done with comparatively harmless substances.

[1] *The Analyst*, February 1906.

CHAPTER XXXI

LEGAL CASES

I.—The Use of Preservatives

Prosecutions with reference to the presence of preservatives and colouring matters may be taken under section 3 or 6 of the Food and Drugs Act, 1875. These sections are as under:

'Section 3. No article of food intended for sale shall be mixed, stained or coloured, or powdered, so as to render it injurious to health.'

'Section 6. No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded by such purchaser.

"Under this section no offence shall be deemed to be committed—

'Where any matter or ingredient not injurious to health has been added to the food or drug because it is required for the production or preparation thereof, as an article of commerce in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight or measure of the food or drug, or to conceal the inferior quality thereof.'

It has generally been assumed that only a duly authorized inspector could take samples of foods or drugs for analysis and institute proceedings, but in a recent case in the High Court (Worthington *v.* Kyme, August 1905) the Lord Chief Justice ruled that a medical officer of health, an inspector of nuisances, inspectors of weights and measures, and other people are entitled to take samples and to have them analyzed, and the people who

may take samples may take proceedings when the result of the analysis is ascertained. Of course the purchaser would have to observe all the legal requirements with reference to the division of the sample, delivery to the analyst, &c.

If action is taken under Section 3 it is necessary for the plaintiffs to prove that the preservative or colouring matter present is injurious to health. This is so exceedingly difficult a matter that prosecutions are now more frequently taken under Section 6, the preserved or coloured article being held to be not of the nature, substance or quality demanded by the purchaser, and leaving the defendants to disprove this, or to prove that the preservative or colouring matter is not injurious to health, or that it is a necessary addition to produce an article of commerce.

These prosecutions arise in the Police Courts, with the right of appeal to Court of Quarter Sessions; but the decisions have no binding effect on other Courts, and the conflicting decisions given emphasize the necessity for some modification of the law, and for the formation of some 'Court of Reference' having power to regulate the practices of trade throughout the country. As the law now stands, there is no right of appeal to the High Court save on points of law, and as the decisions with reference to the use of preservatives and colouring matters are almost always on questions of fact, no appeal is usually possible. Committees upon the administration of the Food and Drugs Acts have repeatedly recommended the appointment of a Standing Committee of Reference, with powers to fix standards, &c., but no steps in this direction have been taken by the legislature. An alternative scheme would be for Parliament to give power to Justices to refer to the High Court at the request of either party concerned, debatable questions of importance, such as those affecting the whole of the members of a particular trade.

The present position is admittedly unsatisfactory both from the commercial and administrative point of view.

The subjoined brief account of prosecutions under the Sale of Food and Drugs Acts for the use of preservatives will

probably be of interest, and may prove of value in other cases of a similar character.

Boric Acid.—1. Margarine containing 51 grains of boric acid per pound. Conviction upheld upon appeal to Court of Quarter Sessions. Boadle *v.* Stewart.

This case was first heard before the Liverpool Stipendiary Magistrate on May 30, 1900. For the prosecution Professor Boyce gave evidence as to the non-necessity of a preservative, which might be used to mask the rancidity of the fat. The same proportion of boric acid when administered in milk to kittens produced violent diarrhœa and emaciation. The Public Analyst stated that margarine was usually free from preservatives.

For the defence medical evidence was given to the effect that boric acid in small doses was not injurious to health.

The defendants were convicted and fined 50*l.* and 5*l.* 5*s.* costs. Notice of appeal was given.

The appeal to Quarter Sessions was heard by the Recorder on July 20, 1900. Medical evidence was produced for both sides. The appeal was dismissed, the Recorder stating that from the evidence he was satisfied that boric acid was a drug which, in the hands of competent and skilled men, was capable of being administered for the good of mankind, but that he could not agree that, put indiscriminately into any articles of food, it was a matter or ingredient not injurious to health. As to whether the boric acid were or were not necessary, he held on the evidence that it was not required in the production or preparation of the margarine.

2. Butter containing 25 grains of boric acid per pound. Conviction quashed by Court of Quarter Sessions.

The case was first heard before the Folkestone Bench on August 15, 1901. Evidence for the prosecution as to the injurious qualities of boric acid was given by the Medical Officer of Health, who also stated that preservatives were unnecessary for butter. He was supported by another medical man.

Medical evidence was also given for the defence. The amount of boric acid was returned as 25 grains per pound. The defendant was convicted.

The appeal to Quarter Sessions was heard on October 23, 1901.

The Medical Officer of Health stated that boric acid was liable to cause illness, and that the effects would continue day by day. He had met with cases of intestinal disturbance at the time of year when preservatives were mostly used, and where he knew they had been added. At a religious institution in Dover five of the inmates were taken seriously ill with symptoms of poisoning, and he found that glacialine had been added to the milk. He made blancmange of the milk and gave it to fowls; some of these died, and borax was found in the gizzards and stomachs. Cold storage was quite sufficient, without the use of preservatives. On cross-examination as to the use of salt as a preservative he pointed out that salt was a normal constituent of the body, whereas borax was not. He was cross-examined on the experiments of Liebreich, Chittenden, and Tunnicliffe and Rosenheim, and it was suggested that the fowls mentioned above had died of ptomaine-poisoning. Drs. Tunnicliffe, Luff, Thresh, Bell, and others had been retained for the defence, but were not called upon for evidence. The conviction by the Magistrates was quashed.

3. Butter containing 84 grains of boric acid per pound. Birmingham, May 1899. Police Court proceedings under section 6. Food and Drugs Act. Convicted.

4. Butter containing 63 grains of boric acid per pound. Birmingham, May 1899. Police Court proceedings under section 6. Convicted.

5. Butter containing 84 grains boric acid per pound. Oxford, February 1900. Police Court proceedings under section 6. Convicted.

6. Butter containing 63 grains boric acid per pound. Birmingham, April 1901. Police Court Proceedings under section 6. Convicted.

7. Butter containing 64 grains boric acid per pound. Southwark, April 1901. Police Court proceedings under section 6. Convicted.

8. Butter containing 68 grains boric acid per pound. Heywood, September 1901. Police Court proceedings under section 6. Convicted.

9. Butter containing 54 grains boric acid per pound. Birmingham, November 1901. Police Court proceedings under section 6.

The Medical Officer of Health gave evidence for the prosecution, alleging the injurious effect of boric acid, and stated that he did not prosecute unless the amount exceeded 23 grains per pound. For the defence the Folkestone case was quoted (2). The Bench considered that an excessive amount had been used, and convicted.

10. Butter containing 20 grains boric acid per pound. Bootle, November 1902. Police Court proceedings under section 6. Convicted.

11. Butter containing 70 grains boric acid per pound. Worship Street, London, February 1904. Police Court proceedings under section 6. Convicted.

12. Butter containing 55·3 grains boric acid per pound. Bamber Bridge, December 1904. Police Court proceedings, under section 6.

Evidence for the prosecution was given by the Medical Officer of Health for the Lancashire County Council. He pointed out that the Departmental Committee recommended a maximum quantity of 35 grains per pound, and he held that any further amount was unnecessary and undesirable. He could not say that the amount present would be injurious to health, or that it had been added for the purpose of increasing the weight or making a larger profit. For the defence it was contended that on the evidence there was no case, and that the recommendations of the Departmental Committee had not become law. The Bench held that the purchaser had not obtained what he asked for, and convicted.

13. Clotted cream containing 0·464 per cent. of boric acid (32½ grains per pound). Westminster, November 1899. Police Court proceedings under section 6. Whipps *v.* Hudson Bros. For the prosecution, after the Public Analyst's evidence, Mr. Droop Richmond, chemist to the Aylesbury Dairy Co., stated that his Company were able to dispense with the use of preservatives. Professor Corfield said that the quantity of boric acid present was sufficient to cause injury to health, that clotted cream was given to children, and that the half-pound jar contained 16 grains, the maximum dose of an adult. This evidence was supported by Dr. Hill (Medical Officer of Health for Birmingham), Dr. F. I. Allan (Medical Officer of Health for Westminster), and others. For the defence Drs. Gibb, Pattison, Marsh, Bryden, and Bond were called, and also Professor Attfield, F.R.S., Mr. Stokes, F.I.C., and Mr. Lloyd, F.I.C. The Bench, however, convicted.

Since 1900, apparently every prosecution with one exception for the use of boric acid in milk has been successful, convictions being obtained. Only one appeal appears to have been made to the Court of Quarter Sessions, and in this instance the appeal failed, though the penalty was reduced. The amounts of acid added varied from 4·8 grains to 24 grains per pint.

Under the circumstances one or two cases only need be referred to.

14. Milk containing 7 grains of boric acid per pint. Southwark, October 1902. Police Court proceedings. Convicted.

An appeal was heard at the Newington Quarter Sessions. For the prosecution the recommendations of the Departmental Committee were quoted, and the Medical Officer of Health, the Public Analyst, and Professor Halliburton gave evidence as to the danger to be apprehended from the use of boric acid in milk. The Public Analyst for Paddington gave evidence for the defence. The conviction was affirmed, with a somewhat reduced penalty.

15. Milk containing 62·4 grains boric acid per gallon.

Maidstone, September 1903. Police Court proceedings. Convicted.

Dr. Thresh for the prosecution said: 'He had never condemned the use of preservatives *in toto*, as he believed that in many cases they might be used with advantage both to the producer and consumer, and he regarded boric acid as one of the most generally useful and least harmful of all chemical preservatives.

'On the other hand he had strong objections to preservatives being used where such were unnecessary, and in articles of food likely to be used by the very young, especially infants, as was the case with milk.

'By the use of boracic acid, uncleanly milk, which more rapidly decomposes than "clean" milk, could be more easily foisted on the public. One day's milk could be kept over and sold the next day as fresh milk, and the public be imposed upon. Such being the case, carelessness in the cowshed, in the milking, in the scalding and cleansing of cans was fostered. Filth microbes remain undetected in the milk and might deleteriously affect persons, especially young children, consuming it.

'The object of recent legislation, of bylaws adopted in nearly all districts, of the efforts of all Medical Officers of Health and Sanitary Inspectors, was to ensure clean cowsheds, clean milk, and clean vessels to contain it. Evidences of carelessness, and uncleanliness were concealed by the use of preservatives, and for this reason he very strongly objected to their use.

'Milk, properly collected, stored, and refrigerated, can always be delivered to the consumers in a satisfactory condition. Boric acid does not kill the organisms in milk, it merely retards the growth of certain of them for a time. Others it does not even retard in the quantity generally used. Organisms derived from sewage and manure grow rapidly in milk, and rapidly turn it sour, and may, under certain circumstances, produce poisonous compounds. If a milk turns sour before there is time to deliver it, it is an indication that it is not safe to use,

especially for infants, in whom it would cause indigestion and diarrhœa. The use of boric acid conceals this defect and does not remedy it, as the change continues when the milk is taken into the system, the harmful bacteria not being destroyed.

'The action of boric acid on digestion has been carefully studied, and it has been asserted that where an animal has not developed its full digestive powers boric acid is practically a slow poison, preventing digestion, causing diarrhœa, emaciation and death. So very many infants die with such symptoms that it was, in his opinion, criminal to give them a milk believed to produce similar symptoms in animals.'

16. (*a.*) Milk containing 13 grains boric acid per pint. Wakefield, August 1904. Police Court proceedings. Convicted.

The Public Analyst, for the prosecution, pointed out that whilst boric acid prevented certain forms of decomposition, other forms proceeded unchecked. An infant taking one pint of this milk per day would receive almost the maximum dose.

(*b.*) Milk containing 4·8 grains of boric acid per pint. Wakefield, October 1905. Police Court proceedings. Case dismissed.

Dr. Kaye, Medical Officer of Health for the West Riding County Council, gave evidence for the prosecution. Dr. Bradshaw, of Liverpool, for the defence, stated that since the use of preservatives in milk had been discontinued the infantile death-rate in Liverpool, mainly due to diarrhœa, had largely increased. The Bench dismissed the case on the grounds that it was not proved to their satisfaction that the amount of boric acid present in the milk was injurious to health.

17. Butter containing 68 grains of boracic acid per pound. Heywood, October 1, 1901. Convicted, fined 1*l.*

18. Shrimps containing 61 grains of boracic acid per pound. Liverpool, January 18, 1902. Convicted, fined 10*s.*

19. Shrimps containing 46 grains of boracic acid per pound. Ormskirk, July 15, 1902. Convicted, fined 5*l.*

20. Shrimps containing 45 grains of boracic acid per pound. Rochdale, September 26, 1902. Dismissed on technical objection.

21. Shrimps containing 40 grains of boracic acid per pound. Wigan, October 1902. Dismissed on technical objection.

22. Butter containing 120 grains of boracic acid per pound. Bootle, November 1902. Convicted, fined 40*s*.

23. Sausages containing 85 grains of boracic acid per pound. Bournemouth, October 3, 1903. Convicted, fined 30*s*.

24. Butter containing 76·3 grains of boracic acid per pound. West London Police Court, November 14, 1903. Summons dismissed.

25. Butter containing 70 grains of boracic acid per pound. Worship Street Police Court, February 20, 1904. Convicted, fined 40*s*.

26. Butter containing 1·4 per cent. boracic acid. Birmingham, October 13, 1904. Dismissed on warranty.

27. Sausages containing 30 grains of boracic acid per pound. South Western Police Court, October 22, 1904. Convicted, fined 20*s*.

28 Sausages containing 60 grains of boracic acid per pound. In this case Dr. Brash, the Medical Officer of Health for the City, deposed that boracic acid was not a proper preservative to be used in any food. Exeter, January 21, 1905. Convicted, fined 5*s*.

29. Butter containing 94 grains of boracic acid per pound. Worship Street Police Court, February 11, 1905. Dismissed.

30. Margarine containing 0·7 per cent. boracic acid. Liverpool, June 10, 1905. Convicted, fined 1*l*.

31. Butter containing 53·9 grains of boracic acid per pound. Widnes, July 1905. Dismissed.

32. Butter containing 1 per cent. boracic acid. Mistley, August 20, 1905. Convicted, fined 10*s*.

33. Potted shrimps containing boracic acid. Blackpool, October 21, 1905. Convicted, fined 10*s*.

34. Butter containing 60 grains of boracic acid per pound.

Worship Street Police Court, October 2, 1905. Convicted, fined 3*l.*

35. Sausages containing 41 grains of boracic acid per pound. Worship Street Police-Court, December 19, 1905. Convicted, fined 20*s.*, but case stated for opinion of High Court.

36. Potted shrimps containing 47 grains of boric acid per pound. Leeds, October 1902. Police Court proceedings. Case dismissed.

The chief witness for the prosecution was the Medical Officer of Health, who pointed out that boric acid was not a normal constituent of the body, and that it was liable to produce deleterious effects when administered internally. Witnesses were also called to prove that shrimps could be potted without the use of preservatives, and would keep for a reasonable length of time. For the defence the dealer stated that preservatives were absolutely necessary if the shrimps were to be kept more than a few days, and a medical witness expressed the opinion that the quantity of boric acid present was quite harmless. The Stipendiary Magistrate was assisted in his decision by the fact that the Departmental Committee recommended limitations in the use of boric acid only in the cases of milk, cream, butter, margarine, and invalid preparations.

Formalin.—In all the cases, with one exception, in which dealers have been prosecuted for the use of formalin in milk, convictions seem to have been obtained, and no appeal has been attempted.

37. Milk. Formalin present, quantity not stated. Liverpool, March 1900. Convicted.

38. Milk. Formalin present, 1 in 50,000. Manchester, June 1901. Convicted.

For the prosecution the Public Analyst stated that formalin rendered milk less digestible, that by its use it was possible to sell stale milk as fresh, and that even 1 part in 100,000 would be injurious to children. Professor Boyce stated that he had fed kittens with milk containing 1 in 50,000 of formalin, that they lost weight, suffered from diarrhœa, and died; that

formalin introduced into the stomach neutralized the gastric juice, and also injured the cells of the mucous membrane.

For the defence Dr. Rideal, in evidence, said that it was entirely a matter of quantity present; that the digestion of milk containing 1 part of formalin per 100,000 was only retarded as compared with pure milk in the proportion of forty-five to forty-four minutes. The Stipendiary, in giving judgment, said it had been proved to his satisfaction that formalin was so volatile that it was impossible to ascertain accurately the amount which had been added to the milk, but that on the evidence there was at least 1 part in 50,000. He considered it impossible to contend that formalin was not injurious to health.

39. Milk. Formalin present, 1 in 100,000. Lancashire County Police Court, January 1902. Convicted.

40. Milk. Formalin present, 1 in 200,000. Leigh, September 1902. Convicted.

41. Milk. Formalin present, 1 in 100,000. Lambeth, October 1902. Convicted.

42. Milk. Formalin present, 1 in 100,000. Lambeth, October 1902. Convicted.

43. Milk. Formalin present, 1 in 100,000. Barrow, November 1902. Dismissed.

In this case the defendant stated that formalin had been used for cleansing the cans, and had not been added to the milk. The Bench apparently accepted this statement, saying that the formalin had been used innocently.

44. Milk. Formalin present, 1 in 100,000. Salford, October 1902. Convicted.

45. Milk. Formalin present, 1 in 25,000. Widnes, November 1903. Convicted.

46. Milk. Formalin present, quantity not stated. Ashton, October 1903. Convicted.

The defence in this case was that the preservative used was sold as 'concentrated essence of limes.'

47. Milk. Formalin present, 1 in 100,000. Birmingham, January 1904. Convicted.

48. Milk. Formalin present, 1 in 100,000. Birmingham, January 1904. Convicted.

49. Milk. Formalin present, 1 in 20,000. Greenwich, August 1904. Convicted.

50. Milk. Formalin present, 1 in 33,000. Greenwich, August 1904. Convicted.

51. Milk. Formalin present, 1 in 25,000. Harleston, September 1904. Convicted.

The defendant pleaded that he had been asked by his customers to add a little formalin, and that he was unaware that it was injurious.

52. Milk. Formalin present, 1 in 100,000. Greenwich, September 1904. Convicted.

For the prosecution, the Medical Officer of Health for Lewisham stated that after taking daily a pint of milk containing 1 part of formalin in 100,000 for ten days, he felt a considerable amount of discomfort and nausea. He considered it must be deleterious, especially to young and delicate children. It was not possible to estimate the whole of the formalin that had been added to milk. He was supported by the medical superintendent to the Lewisham Infirmary, who said that formalin was an irritant poison. He had made experiments and found that he could tolerate formalin up to 1 part in 10,000, after which it made him sick. There was no doubt that even 1 part in 100,000 hindered digestion and was injurious.

For the defence Dr. Rideal said he had considerable experience of preservatives and had never known formalin to be injurious to health, though he had given it to his own children, and to kittens and other animals. There was no evidence that 1 part in 100,000 was harmful; he had given his son twenty times this amount. He had made experiments with fish, and a goldfish throve in water containing 1 part of formalin in 40,000. One part in 5,000 did not affect the heart of a frog.

53. Milk. Formalin present, 0·00125 per cent. Lambeth, November 1904. Convicted.

54. Milk. Formalin present, 0·00075 per cent. Lambeth, November 1904. Convicted.

55. Milk. Formalin present, 0·0016 per cent. Southwark, November 1904. Convicted.

56. Milk. Formalin present, 0·001 per cent. Woolwich, November 1904. Convicted.

Salicylic Acid.—The decisions given with reference to the use of this acid present no uniformity, though many convictions have been obtained. No case appears to have gone up to the High Courts, but in some instances the convictions of the Police Courts have not been upheld on appeal to the Court of Quarter Sessions.

57. Ginger wine containing 13 grains of salicylic acid per pint. Liverpool, October 1900. Police Court proceedings. Dismissed.

For the prosecution Professor Boyce stated that he had fed kittens four weeks old with milk containing a small quantity of salicylic acid; the effects had been most injurious. Salicylic acid was unnecessary and harmful. The Public Analyst stated that salicylic acid was a foreign ingredient to ginger wine. Out of thirty-three samples analyzed the greatest quantity he had ever found was 4 grains per pint.

For the defence two medical men considered that the quantity of salicylic acid which would be consumed in the ginger wine would be harmless.

A member of the firm stated that when the wine was made from ginger, and not from an essence, a preservative was essential.

58. Ginger wine containing 13 grains of salicylic acid per pint. Liverpool, February 1901. Police Court proceedings. Dismissed.

59. Ginger wine containing 9 grains of salicylic acid per pint. Leyland, April 1902. Police Court proceedings. Convicted.

60. Raisin wine containing 8·5 grains salicylic acid per pint,

61. Cherry brandy containing 6·0 grains salicylic acid per pint,

62. Orange wine containing 8·5 grains salicylic acid per pint. Chorley, June 1902. Police Court proceedings. All convicted.

63. Orange wine containing 15 grains salicylic acid per pint. Wiltshire County Sessions, August 1902. Convicted.

64. Orange wine containing 7·1 grains salicylic acid per pint. Chester, January 1903. Convicted.

65. Orange wine containing 10 grains salicylic acid per pint. Pontypridd, July 1903. Convicted.

66. Elderberry cordial containing 5 grains salicylic acid per pint. Bury, October 1903. Convicted.

67. Ginger wine containing 7·2 grains salicylic acid per pint. Coagh, May 1904. Dismissed.

The only evidence for the prosecution was the Analyst's certificate. For the defence witnesses were called who testified as to the harmlessness of salicylic acid in the proportion present in the samples.

68. Ginger wine containing 7·2 grains of salicylic acid per pint. Belfast Petty Sessions; appeal before the Recorder, September 1904. Conviction upheld.

The case was first heard at the Belfast Petty Sessions, when the defendant was convicted under section 6 and fined 20*s*. It was contended that as ginger wine had been known for a century or more, and as salicylic acid was a comparatively recently discovered drug, its use could not be essential in the making of ginger wine, that the larger manufacturers did not use it, and that it was injurious. For the defence it was alleged that either a preservative or alcohol was required to prevent fermentation, and that the amount of salicylic acid used was too small to be harmful.

The appeal was heard before the Recorder of Belfast on September 23, 1904.

The City Analyst proved that the wine contained 7·2 grains of salicylic acid per pint and 12·2 per cent. of alcohol, and stated that the latter was sufficient to preserve the wine from fermentation.

Dr. O'Neill stated that he had been practising medicine for twenty-seven years, and before that had had practical experience in the making of ginger wine. He read formulæ for its preparation in Muspratt's 'Dictionary of Chemistry,' 1860, and also in the 'Chemist and Druggist' of 1890. Ginger wine contained from 5 to 12 per cent. of alcohol produced by fermentation in the course of manufacture, and this was sufficient to preserve it. Salicylic acid was a dangerous drug, especially dangerous when given in any quantity to persons suffering from inflammation of the heart, liver, or kidneys. Dr. Stanley B. Coates and Dr. Torrens supported Dr. O'Neill's evidence.

For the appellants, Mr. Charles Huxtable, pharmaceutical and analytical chemist, stated that he had had experience in the manufacture of ginger wine for four years, and that the addition of a preservative was essential. Salicylic acid to the extent of 7·2 grains per pint would be harmless, and less than this quantity would be ineffectual. Ginger wine might contain 16 to 20 per cent. of proof spirit, but this would be insufficient to prevent fermentation. When cross-examined on the experiments quoted in the Report of the Departmental Committee as to the effects of salicylic acid on the digestive ferments, it was stated that he had carried out experiments on the point, and found that there was no retardation induced by salicylic acid when present up to 10 grains per pint.

Sir William Whitla, Professor of Materia Medica, Queen's College, Belfast, said the pharmacopœial dose of salicylic acid was 5 to 20 grains, but it was not unusual to give as much as 120 grains in the day. Anyone taking 120 grains of salicylic acid through the wine would have to consume also half a stone of sugar; he did not think there was a particle of evidence to show that it did harm in small doses. He believed the statements continually made in books about

salicylic acid and its effects upon the heart and kidneys arose at the time when it was impossible to get the drug pure, and that the injurious effects were due to the impurities. With the present methods of purification the cardiac depression was not found even when enormous doses were given. He thought salicylic acid was preferable to alcohol as a preservative. It was, he believed, being introduced into beer and light wines, but if a man took a couple of bottles of beer, a bottle of cider, and a bottle of claret, he would absorb only 30 grains of salicylic acid, and it would do him less harm than the alcohol.

Dr. A. Montgomery gave supporting evidence.

The Recorder, in giving his decision, said that the question resolved itself into whether the drug was necessary or whether there was any doubt as to its being injurious, because if unnecessary it should not be introduced, and if injurious it should not be introduced. Ginger wine had existed long before the drug was introduced into it. Was the wine better than it used to be? Having been existent so long without the drug he could not see how the drug was necessary, and if not required, it appeared to him that it ought not to be introduced into the wine. The decision of the Magistrates was therefore confirmed, and the appeal dismissed.

69. Lime-juice cordial containing 8 grains of salicylic acid per pint. Southwark, October 1903. Dismissed.

The Medical Officer of Health, in evidence, stated that salicylic acid was a drug which, under certain circumstances, produced injurious effects, and that as present in the sample it was prejudicial to health. In previous years some 85 per cent. of temperance drinks contained preservatives, but the latter were not so extensively used now.

Dr. Tebb gave his opinion as to the injurious effects of salicylic acid in persons suffering from heart disease and kidney complaints. Any beverage containing a preservative should be labelled to that effect. The conclusions of the Departmental Committee were quoted.

For the defence, the manager of the firm stated that sali-

cylic acid had been used by the trade for twenty years, and that it was necessary to prevent the bursting of the bottles. He believed that nineteen out of twenty manufacturers used it. In spite of the recommendations of the Committee he thought salicylic acid was necessary for lime juice, and 1 grain per pint was insufficient. Their consulting chemist stated that out of eighteen samples examined, seventeen contained salicylic acid in proportions varying from 1½ to 12 grains per pint.

Further evidence was given by Mr. Bannister, Dr. Luff, and Dr. Thresh. The last-named considered that the natural citric acid of the fruit might become more harmful than the salicylic acid, and would be more injurious to the kidneys. No evil effect had ever been traced to the use of the preservative.

Dr. Abbott Anderson stated that the mischief alleged to be due to salicylic acid was due to impurities, but that it could now be procured in a pure state.

In his decision, the Magistrate stated that the onus of proving the injurious effects of salicylic acid used in the proportions present lay on the prosecutors, and this they had failed to do, relying almost entirely on theoretical evidence and the findings of the Departmental Committee. These grounds were not conclusive, or even satisfactory, to him for forming a judgment. Neither of the witnesses for the prosecution had made a special study of the effects of salicylic acid, whilst for the defence several witnesses had given evidence in its favour. He had no evidence as to the kind of persons who habitually used the beverage except that they were generally teetotalers or children. He himself was prepared to accept the statement of Dr. Thresh that 'the general experience is that salicylic acid in food has been used by hundreds and thousands of persons day by day, and no one has ever reported an authenticated case of any sign of danger from it.' The information was therefore dismissed without costs.

70. Jam containing 1·7 grains salicylic acid per pound. Llanrwst, November 1899. Police Court proceedings. Case dismissed.

71. Jam containing 2·6 grains salicylic acid per pound. Stockport, August 1903. Police Court proceedings. Conviction upheld at Quarter Sessions.

On August 25, 1903, the defendant was convicted at the Stockport Police Court.

The appeal was heard in October 1903, before the Cheshire Quarter Sessions at Knutsford.

The chief witness for the prosecution was Dr. Delépine, who stated that a preservative was not necessary in jam making if the fruit were in good condition; it was only when the fruit was too moist that jam would not keep without a preservative. Salicylic acid was a powerful poison, and the continuous taking of minute doses would be injurious to children and weakly persons.

For the defence, the manufacturer, Mr. J. Greenhalgh, Reddish, stated that they had been using salicylic acid in jam making for twenty-five years; it was not used to conceal the inferior quality of the fruit, but to prevent mould and mildew and to check fermentation. It would be very difficult to manufacture jam without it, and bad fruit could not be made into good jam by the use of a preservative.

Similar evidence was given by other manufacturers, who, however, admitted that since the issue of the Report of the Departmental Committee, they had reduced the quantity of salicylic acid to 2 grains or less per pound.

Medical witnesses and analytical chemists gave evidence as to the harmlessness of the small quantity of preservative present in the sample of jam in question.

The Bench upheld the conviction; they did not consider that the jam was of the nature, substance, and quality demanded in that it contained salicylic acid. They were influenced by the fact that jam forms a staple article of diet among children in working-class districts, and they could not help thinking that even in minute doses, repeated, the drug would be injurious. In view of the Report of the Departmental Committee they considered that more than 1 grain per pound would be unsafe.

72. Jam containing 2·25 grains of salicylic acid per pound. Guisborough, October 1903. Police Court proceedings. Case dismissed.

For the defence the manufacturer stated that the use of salicylic acid had been the custom of the trade for twenty-five years, and that $2\frac{1}{4}$ grains per pound was the smallest quantity which would prevent fermentation. That 1903 was a wet year, and the fruit being unduly moist, preservatives were especially necessary. Two medical witnesses considered that the quantity of salicylic acid present would be harmless.

73. Marmalade containing 5·5 grains of salicylic acid per pound. Liverpool, February 1904. Convicted.

74. Jam containing 3·25 grains of salicylic acid per pound. Manchester, January 1904. Convicted.

Evidence for the prosecution was given by Dr. Sargeant, Medical Officer of Health to the Lancashire County Council. He agreed with the Departmental Committee that any preservative added should not exceed 1 grain per pound: $3\frac{1}{4}$ grains might not be injurious to the health of adults, but would be an amount inadvisable for children. It was possible that tne preservative might be used to disguise inferior fruit, and he found personally that, by using equal quantities of fruit and sugar, jam kept well enough without preservatives.

For the defence it was submitted that a small quantity of preservative was necessary in order that the jam might be in a fit state for carriage or consumption, and that, to keep jam for at least fifteen months under varying conditions of temperature and atmosphere, salicylic acid was necessary, whatever might be true of home-made jam for household purposes.

Dr. Graham, of the Wigan Infirmary, stated that he had never met with a case of poisoning from the use of salicylic acid, and that he instructed his own cook to use 2 to 4 grains of the preservative to the pound of jam.

The Stipendiary Magistrate convicted on the grounds that, as the Departmental Committee, after examining witnesses of the highest scientific knowledge, considered that 1 grain per

pound was sufficient, he could not support the contention of the defence that 3¼ grains per pound was a necessary quantity.

75. Jam containing 2·5 grains salicylic acid per pound. Conway, May 1904. Dismissed. Evidence was given that salicylic acid was frequently used by the trade, and that in twelve samples examined the average amount present was 2·8 grains per pound, that 1 grain per pound as recommended by the Departmental Committee was worse than useless, and that minute traces of salicylic acid were found in all fruits. Medical evidence was also called as to the harmlessness of the small quantity of preservative present.

76. Orange wine containing 10 grains of salicylic acid per pint. Dudley, February 1, 1902. Case dismissed. Dr. Wilkinson, Medical Officer of Health, stated that in his opinion this quantity would be injurious to health if continually used. Evidence for the defence was given by Mr. A. Gordon Salamon and Dr. A. P. Luff.

77. Cherry brandy containing 6 grains of salicylic acid per pint. Chorley, June 14, 1902. Convicted, fined *5l.* and costs.

78. Orange wine containing 15 grains of salicylic acid per pint. Melksham, August 1903. Convicted, fined *5l.*

79. Orange wine containing 7·78 grains of salicylic acid per pint. Chester, January 10, 1903. Convicted, fined *5l.* and costs.

80. Orange wine containing 10 grains of salicylic acid per pint. Pontypridd, August 8, 1903. Convicted, fined *1s.*

81. Jam containing 2·6 grains of salicylic acid per pound. Southport, August 29, 1903. Convicted, fined *5s.* This conviction was subsequently confirmed on October 24, 1903, by the Cheshire Quarter Sessions on the ground that the quantity exceeded the amount recommended by the Departmental Committee.

82. Elderberry cordial containing 5 grains of salicylic acid per pint. Bury, October 17, 1903. Convicted, fined *20l.*

83. Ginger wine containing 7·28 grains of salicylic acid per pint. Cookstown, June 18, 1904. Convicted, fined *5s.*

84. Ginger wine containing 8·7 grains of salicylic acid per pint. Dungannon Quarter Sessions, June 25, 1904. The local Magistrates had convicted defendant, but upon appeal evidence was given by Professor Tichborne, Dr. Graves and Dr. Saggers to the effect that the quantity in question was necessary as a preservative, and that no harm could result from its use. The appeal was allowed and the conviction quashed.

85. Belfast Quarter Sessions, October 1, 1904. There was an appeal against a conviction in respect of orange wine containing 7·2 grains of salicylic acid per pint. Evidence for the defence was given by Sir William Whitla, Belfast, and Dr Alexander Montgomery. The decision of the Magistrates was upheld and the conviction confirmed.

86. Ginger wine containing 13 grains of salicylic acid per pint. Southwark Police Court, January 14, 1905. Case dismissed.

87. Orange wine containing 3 grains of salicylic acid per pint. Brentford, February 25, 1905. Case dismissed.

88. Ginger wine containing 2·4 grains of salicylic acid per pint. Eglinton, March 11, 1905. Convicted, fined 2*l*.

89. Ginger wine containing 2·7 grains of salicylic acid per pint. Portrush, April 1, 1905. Case dismissed.

90. Ginger wine containing 6 grains of salicylic acid per pint. Salisbury, July 29, 1905. Convicted, fined 20*s*.

91. Lime juice cordial containing 6 grains of salicylic acid per pint. Southwark Police Court, March 7, 1906. Case dismissed.

92. Jam containing 2·5 grains salicylic acid per pound. Altrincham, May 1904. Dismissed.

93. **Glucose.**—The following case is of considerable interest, and is included here because it was successfully contended that the addition of glucose to marmalade not only prevented crystallization, but also had a tendency to prevent mildew and fermentation:

Smith *v.* Wisden. Appeal; King's Bench Division, November 1901; before Alverstone, L.C.J., Darling, J., and

Channell, J Conviction of West Sussex Quarter Sessions quashed.

The marmalade was purchased by an Inspector of the West Sussex County Council, and was found on analysis to contain 13 per cent. of glucose. It was labelled 'Crosse and Blackwell's Pure Orange Marmalade, manufactured entirely from Seville oranges, and warranted pure.' The defendant was convicted at the Worthing Court of Summary Jurisdiction, and the conviction was confirmed by the West Sussex Quarter Sessions.

It was proved at Quarter Sessions that glucose was composed of 40 per cent. dextrose, 40 per cent. dextrine, and 20 per cent. water, that it had been employed by many marmalade manufacturers for years, that there was no legal standard for marmalade, and that glucose was not injurious to health, but was used to prevent the marmalade crystallizing, and that it had also a tendency to prevent mildew and fermentation. It was contended, therefore, that the sale was not to the prejudice of the purchaser. The Bench, in confirming the conviction of the Magistrates, found: (1) that in asking for marmalade the purchaser desired to buy a substance composed of oranges cooked or preserved with cane-sugar or beet-sugar, and had not consented to be served with a preserve to which starch glucose had been added; (2) that the sale of the article, which contained 13 per cent. of starch glucose, was to the prejudice of the purchaser; and (3) that it was the sale of an article not of the nature, substance, and quality demanded.

The appeal in the Higher Court of Justice was allowed, on the grounds that the evidence had failed to prove that the article was not of the nature, substance, and quality demanded by the purchaser.

In order to sustain such a contention Alverstone, L.C.J., pointed out that the alteration must be to the prejudice of the purchaser, and that the prejudice must be that which the ordinary customer suffers: namely, by paying for one thing and getting another of inferior quality. The words inserted in the

clause (section 6) are intended to show that the offence is not simply the giving of a different, but the giving of an inferior, thing to that demanded and paid for.' In the case under consideration it had been proved to the Magistrates that glucose had been employed in the manufacture of marmalade for a period of fifteen years by a large number of manufacturers, but not by all. Therefore it is plain that the Magistrates found as a fact that it was an alternative ingredient in marmalade. They found that there is no standard for marmalade, but that glucose was a frequent but not invariable constituent in varying the receipt. They found also that the use of glucose to the extent contained in the analyzed sample was not injurious to health, that it prevented the marmalade from crystallizing, and had a tendency to prevent mildewing and fermentation. Consequently the purchaser got an article which, if it differed at all, was different in the sense that it was better. The Justices, therefore, were not justified in coming to the conclusion that the sale was to the prejudice of the purchaser.

This decision was followed in the Sheriff Court, Scotland, in 1905 after much evidence and argument.

II.—Cases relating to Copper in Foods

94. Peas containing 2·53 grains of sulphate of copper per pound. Rochdale, January 25, 1902. Convicted, fined 5*s*.

95. Peas containing 2·5 grains of sulphate of copper per pound. February 1, 1902. Convicted, fined 21*s*.

96. Peas containing 1 grain of metallic copper per pound. Blackpool, April 12, 1902. Convicted, fined 5*s*.

97. Peas containing 4 grains of sulphate of copper per pound. Manchester, June 14, 1902. Case dismissed.

98. Peas containing 5 grains of sulphate of copper per pound. Manchester, July 1902. Convicted, fined 1*s*.

99. Peas containing 2·45 grains of crystallized sulphate of copper per pound. Aberdeen, August 2, 1902. Convicted, fined 2*l*. 10*s*.

100. Peas containing 3 grains of sulphate of copper per pound. Ulverstone, August 30, 1902. Convicted, fined 5*l.*

101. Peas containing $2\frac{1}{4}$ grains of sulphate of copper per pound. Bury, September 22, 1902. Convicted, fined 2*l.*

102. Peas containing 2 grains of sulphate of copper per pound. Lambeth, November 29, 1902. Convicted, fined 10*s.*

103. Peas containing 2·5 grains of sulphate of copper per pound. Lambeth, December 1902. Convicted, fined 20*s.*

104. Peas containing 2·8 grains of sulphate of copper per pound. January 10, 1903. Convicted, fined 20*s.*

105. Peas containing 3·9 grains of sulphate of copper per pound. Marlborough Street, February 21, 1903. Convicted, fined 5*l.*

106. Peas containing 3·57 grains of sulphate of copper per pound. Southwark Police Court, March 14, 1903. Convicted, fined 20*s.* In this case Dr. Brown, the Medical Officer of Health for Bermondsey, said the amount in question was very injurious to health. If a person happened to eat a pound of peas he would be seized with vomiting and diarrhœa.

107. Peas containing 3·37 grains of sulphate of copper per pound. Dudley, August 15, 1903. Convicted, fined 20*s.*

108. Peas containing 1·33 grain of sulphate of copper per pound. Dudley, September 15, 1903. Convicted, fined 20*s.*

109. Peas containing 2·66 grains of sulphate of copper per pound. Dudley, September 19, 1903. Convicted, fined 20*s.*

110. Peas containing 0·44 grain of sulphate of copper per pound. Dudley, September 26, 1903. Convicted, fined 40*s.*

111. Peas containing 2·4 grains of sulphate of copper per pound. October 21, 1903. Convicted, fined 10*s.*

112. Peas containing 0·5 grain of sulphate of copper per pound. Barrow, January 9, 1904. Dismissed.

113. Six cases of peas containing quantities varying from 1·7 to 2·9 grains per pound. Southwark Police Court, January 23, 1904. Convicted, each fined 20*s.* In this case evidence was given by Dr. Robert Hutchison, of the London Hospital, and Dr. R. A. Young, of the Middlesex Hospital.

114. Nine cases of peas containing sulphate of copper in varying quantities, the highest being 3·1 grains per pound. Bournemouth, April 16, 1904. Conviction in one case, fined 30*s.*; remaining cases withdrawn.

115. Peas containing 2·5 grains of sulphate of copper per pound. Marlborough Street, June 4, 1904. Convicted, fined 5*l.* Haricot beans containing 2·21 grains of sulphate of copper per pound. Same court. Convicted, fined 4*l.*

116. Peas containing 0·84 grain of sulphate of copper per pound. July 30, 1904. Convicted, fined 40*s.*

117. Peas containing $\frac{4}{5}$ grain of sulphate of copper per pound. Dunfermline, August 13, 1904. Case dismissed on ground that person who buys preserved peas must be assumed to know that something has been added to preserve them.

118. Peas containing 3·4 grains of sulphate of copper per pound. Bow Street, August 20, 1904. Convicted, fined 40*s.*

119. Peas containing 3·24 grains of sulphate of copper per pound. Blackpool, December 17, 1904. Convicted, fined 5*l.*

120. Peas containing 2·96 grains of sulphate of copper per pound. Liverpool, February 11, 1905. Convicted, fined 3*l.*

121. Peas containing $2\frac{3}{4}$ grains of sulphate of copper per pound. Derry, April 8, 1905. Convicted, fined 3*l.*

122. Peas containing $2\frac{1}{4}$ grains of sulphate of copper per pound. Derry, March 18, 1905. Convicted, fined 3*l.*

123. Peas containing $2\frac{1}{2}$ grains of sulphate of copper per pound. Barrow, April 13, 1905. Convicted, fined 5*l.*

124. Peas containing 3·4 grains of sulphate of copper per pound. Marlborough Street, June 24, 1905. Convicted, fined 5*l.*

125. Peas containing 2·34 grains of sulphate of copper per pound. Westminster, July 29, 1905. Convicted, fined 1*l.*

126. Peas containing 3·22 grains of copper per pound. Ramsgate, October 14, 1905. Convicted, fined 5*s.* In a considered judgment the Ramsgate Stipendiary stated that the preponderance of scientific opinion sufficiently established the

fact that the quantity of copper in this case rendered the peas injurious.

127. Peas containing 3 grains of sulphate of copper per pound. Birkdale, October 21, 1905. Convicted, fined 40*s*.

128. Spinach containing 5 grains of sulphate of copper per pound. Westminster, October 2, 1905. Convicted, fined 40*s*.

129. Spinach containing 7½ grains of sulphate of copper per pound. Westminster, December 9, 1905. Convicted, fined 3*l*.

130. Spinach containing 3·32 grains of sulphate of copper per pound. Marlborough Street, December 9, 1905. Convicted, fined 5*l*. In this case Dr. F. J. Smith, of the London Hospital, deposed that sulphate of copper in such small quantities was perfectly harmless.

At the same Court on the same day two other defendants were fined for selling peas containing 3·4 and 4·47 grains of sulphate of copper respectively.

131. Spinach containing 4·75 grains of sulphate of copper per pound. Liverpool, January 13, 1906. Convicted, fined 40*s*.

132. Copper in spinach. Police Court proceedings, November 9, 1905. Conviction. The case was tried at Marlborough Police Court on November 9, the Civil Service Co-operative Society, Limited, Haymarket, being charged with selling to the prejudice of the purchaser a tin of spinach containing 0·0166 per cent. of copper (the equivalent of 4·57 grains of copper to each pound of spinach). Dr. F. J. Allan, Medical Officer of Health for Westminster, stated that in his opinion the use of copper in tinned spinach was unnecessary and harmful; he had seen preserved spinach having its natural colour retained without the use of copper. For the defence it was contended that this particular spinach was not sold to the prejudice of the public, inasmuch as its nature was disclosed on the label: sulphate of copper had been recommended as a preservative, and was the only means of keeping spinach in an appetizing form. The Magistrates imposed a fine of 10*l*., with 5*l*. costs.

III.—Important Appeal Cases

133. Copper in peas. Appeal to Quarter Sessions (South London) from the conviction of the appellant for an offence against section 3 of the Sale of Food and Drugs Act, 1875, before E. N. Fenwick, Esq., sitting at the Southwark Police Court, May 1896.

The following is an abstract of the judgment of the Court taken from the 'Justice of the Peace,' May 30, 1896. (The amount of copper in the peas was taken at 3 grains in the pound.)

'Guy and Ferrier, in 1895, say that copper may be used medicinally on a human subject in doses from half a grain to 2 grains as an astringent, and from 5 grains to 10 grains as an emetic. To animals, the dog especially, the quantity which may be given for considerable periods, without sensible effect, is very large. The same authors also quote recorded instances to show that human beings may take this same drug for a lengthened period without serious symptoms; one of these refers to Raermacher, a man known to the scientific world, who took it for eight months with no effect but a ravenous appetite and painless diarrhœa, but the Court would have difficulty in believing that an unnatural craving for food, and diarrhœa, though painless, do not point to a condition of the system incompatible with a normal state of health. Touissant again is quoted as having taken from 3 to 7½ grains for fourteen days with no symptoms but metallic taste, and as having after taking various preparations of copper for six months remained quite well. Here again arises the question whether a metallic taste is compatible with sound health. The same authors mention a form of disease called copper colic as prevailing among workers in copper. This effect some attribute to the fumes or other influences of the copper itself, others to metal blended with it as alloys. Ogier, Charteris, and Snodgrass are severally quoted to show that the presence of salts of copper in small quantities has no bad influence. It

has been urged in favour of sulphate of copper that it is used as a medical remedy, in doses of a half to 2 grains. It is, however, admitted that the use of it has been worthily discontinued, other more desirable and efficacious appliances having come into vogue. The Court has, however, found its attention drawn to the fact that the administering this drug—where it acts and is acted upon by some already existing derangement of the system, whereby its effects are concentrated—must be regarded in a different light from its being gradually absorbed into the system for a lengthened period. Tschirch[1] has been largely quoted by both sides. He says that salts of copper can cause poisoning and even death to man, but that the experiments show that such results, to say the least, are seldom found, and that mostly after ceasing the taking the parts deranged return quickly to their normal state; but that he cannot regard in the light of such—which from the context seems to mean to such a degree—as lead, antimony, and other poisons. As to colouring he approves of it as rendering food more attractive to the eye, and thus promoting appetite, provided always that no injury to health attaches to the process. In colouring he says—and this is important—that the copper phyllo-cyanate alone acts, that copper leguminate, which is only formed freely when there is too much copper, is to be avoided, as it is useless for the purpose of colouring. The Court must notice here that in the case before it the proportions show one-third of copper phyllo-cyanate and two-thirds of leguminate. He regards as of great importance on principle the question whether copper salts should be allowed in food, in view that it is undoubted that it affects, though slightly, the health if taken in sufficient quantity, and it is desirable to fix a quantity which has been shown to be harmless. This, he says, throws a great responsibility on the hygienic chemist. The quantity allowed by Tschirch varies from 1 in 40,000 to a maximum of 1 in 10,000, whereas in the case before the Court the quantity found is 1 in 8,750, or,

[1] Monograph: *Das Kupler*, Stuttgart, 1893. *Vide* also *Blyth on Foods*, p. 224.

according to the appellant's contention, 1 in 8,772, thus exceeding Tschirch's maximum limit. For colouring purposes his proportion is 18 in 1,000,000, whereas the result in the case before the Court shows 114 in 1,000,000. The same author, however, considers that experiments have not been continued for a sufficiently long time to arrive at anything like certainty on the question. He seems to think that it would be abortive to prohibit absolutely copper in food and drink, because this would be equivalent to prohibiting the plant to absorb it from the ground, and to classify the consumption of bread and chocolate amongst the things injurious to health. The Court have had brought to their notice by the learned counsel for the appellant two prosecutions under this same statute and section in Glasgow, in both of which the defendants were acquitted, but in the former of those cases the quantity charged was 1·4 of added matter. The quantity in the second case was 2·5. The learned Sheriff Birnie declined to convict, because he had no evidence before him of the difference in effect between 1·4 and 2·5. To corroborate the general opinion that copper used for colouring matter is innocuous, the learned counsel for the appellant brought to the notice of the Court that in France there is no restriction as to its use whatever. Though this general statement does not influence the Court in this case, the proceedings of the French Government from time to time are not without interest. It appears that France is by far the largest exporter of preserved fruits and vegetables. In 1853 it prohibited the use of copper salts in preserved articles of food —at first in Paris—but the prohibition seven years later was extended to the whole country on the recommendation of appointed experts, who were of the opinion that, although the quantities extracted from certain samples were small and not likely to produce serious accidents, yet the presence of a highly poisonous substance in proportions without a fixed limit involved a risk which should not be permitted to exist. France, however, even at that time, had 20,000 hands and a capital of 40,000,000 fr. engaged in the manufactures, and

appeals were made against this decision, and it was urged that greening for export should be permitted, but not for home use. At length in 1889, on the report of a consulting committee, prohibition was withdrawn absolutely. On the other hand, in most of the continental countries restrictions are in force. It has also been urged that the upholding of a conviction of this kind would be to seriously interfere with a very large and important branch of trade. The Court are not apprehensive on that score, seeing there are simple means of obviating such a result. But even were it otherwise, the Court do not think that such a consideration should influence their judgment. To quote all the authorities put before the Court in this case would exceed the limits of a judgment. It is to be observed that the proportion of the added foreign substance is in excess of that in all the cases brought forward except in a case at Bristol. After carefully perusing and considering the whole of the evidence oral and written, the Court are forced to the conclusion that, where the opinions of eminent authorities are still in a state of uncertainty, it would be mischievous to countenance an addition of this foreign substance to articles of food in a larger proportion than that which they suggest. The quantity in this case is considerably in excess of that quantity. The Court is therefore of opinion that the conviction should be upheld. The appeal is therefore dismissed.'

134. From the 'Law Times,' March 18, 1905. Copper in peas. King's Bench Division, Friday, November 4, 1904. (Before Lord Alverstone, C.J., Kennedy and Ridley, JJ.). Hull (appellant) *v.* Horsnell (respondent).

Food and Drugs—Preserved peas—Sulphate of copper—Injurious to health—Certificate of analyst—Sale of Food and Drugs Act, 1875 (38 and 39 Vict. c. 63) s. 3.

Under section 3 of the Sale of Food and Drugs Act, 1875, the article of food must be rendered injurious to health by being mixed with some ingredient. It is not sufficient that the ingredient with which the food is mixed is injurious to health. The certificate of the analyst in the case of an alleged

offence under this section is not sufficient, if it complies with the form in the schedule to the Act of 1875, merely because it does not state that the ingredient so mixed 'rendered the article injurious to health.'

Case stated on an information preferred by the respondent against the appellant under the Food and Drugs Act, 1875, charging that the appellant did, on February 19, 1904, unlawfully and wilfully sell to the respondent a certain article of food—to wit, bottled peas—which to the knowledge of the appellant was mixed with a certain ingredient called sulphate of copper, which ingredient was injurious to health, contrary to the Sale of Food and Drugs Acts, 1875–1899.

The respondent, an inspector under the Sale of Food and Drugs Acts, purchased of the appellant, a greengrocer carrying on business at Bexhill, a bottle of preserved peas for the purpose of analysis.

The respondent divided the peas so purchased into three parts, and sent one part to the public analyst, who gave his certificate as follows:

'I, the undersigned public analyst for the administrative county of East Sussex, do hereby certify that I received from yourself on February 20 (per registered parcel post) a sample of bottled peas, No. 14, for analysis (which then weighed about 4½ oz.), and have analyzed the same, and declare the result of my analysis to be as follows:—I am of opinion that the said sample is adulterated with sulphate of copper to the extent of at least 1·87 grains per pound. Observations.—The copper salt has doubtless been added to improve the colour of the peas.'

The respondent proved that the bottle containing the peas bore the following label, 'English Garden Peas . . . Colour preserved with a small portion of sulphate of copper. Finest English Marrowfat Peas. Preserved in Kent.—Petty, Wood & Co., London.'

The public analyst was called for the prosecution, and he proved: (a) That sulphate of copper was a poisonous substance

and injurious to health; (*b*) that sulphate of copper was used to preserve the colour of the peas; (*c*) that he had never known anyone personally, or heard of anyone injured by eating peas containing copper, but that he, the public analyst, suffered from colic if he ate coppered peas; (*d*) that out of eight samples examined by him during the previous quarter, seven contained copper. On behalf of the appellant it was contended that the information did not disclose any offence under the Sale of Food and Drugs Act, 1875, because it did not allege that the admixture of the ingredient called sulphate of copper rendered the article of food—namely, the peas—injurious to health, but merely that the ingredient itself was injurious to health, that therefore the information was bad in law, and the appellant could not be convicted upon it. It was also contended on behalf of the appellant that the certificate of the public analyst did not disclose any offence, and was insufficient, and did not comply with the requirements of the Sale of Food and Drugs Act, 1875.

On behalf of the respondent it was contended that the information did disclose an offence under the Act, that it is sufficient to constitute an offence under the latter part of section 3 of the Sale of Food and Drugs Act, 1875, if the ingredient itself which is mixed with the article of food is injurious to health, and it is not necessary to show that the ingredient renders the article of food injurious to health.

It was also contended that the analyst's certificate was sufficient, being in the form provided by the schedule to the Sale of Food and Drugs Act, 1875, and that the certificate need not disclose any offence. It was contended also that the insufficiency (if any) was remedied by the public analyst being called as a witness to give evidence of the facts.

The Justices were of opinion that sulphate of copper, which was an ingredient in the peas, was injurious to health, and they therefore convicted the appellant, being of opinion that the ingredient necessarily rendered the whole article sold injurious to health.

The questions for the opinion of the Court were: (1) Whether the information disclosed an offence under the Sale of Food and Drugs Act, 1875, and was valid in law; (2) whether the public analyst's certificate was sufficient and valid in law.

Lord Alverstone, C.J.: If the Justices had convicted the appellant of an offence under section 3 of the Sale of Food and Drugs Act, 1875, on the ground that the ingredient which was mixed with the article of food—sulphate of copper—was injurious to health, and not on the ground that the peas by reason of the addition of the sulphate of copper were rendered injurious to health, I am clearly of opinion that the conviction would be wrong. I have no doubt that in order to constitute an offence under section 3 the article of food must be found to be injurious to health by the addition of some ingredient. We have seen the summons which recites the information, and, speaking for myself, I think that the Justices have, in fact, found the article itself—namely, the peas—was injurious to health when they said that the ingredient necessarily rendered the whole article sold injurious to health. As, however, there may be some doubt as to whether they have so found, I think that the case ought to be sent back to them, with directions that if they can find the peas as sold were injurious to health the conviction should stand, but if they find, not that the peas were injurious to health, but that the sulphate of copper, the ingredient with which they were mixed, was, the conviction should not stand.

Mr. Avory has taken a second point—namely, that the conviction cannot stand because the certificate of the analyst is insufficient. (His Lordship read the certificate and continued): It was contended that at the end of the finding the analyst should have added the words, 'which rendered the articles injurious to health,' since the certificate, as it stands, does not show on the face of it that any offence has been committed. I cannot agree with that contention. The analyst could not know with what offence the person would be charged. In my opinion, the certificate is sufficient if it is one which is

in accordance with the terms of the schedule, and sets out the description of the goods sent for analysis, the weight, and the other requirements of the schedule.

Kennedy and Ridley, JJ., agreed.

Case remitted to the Justices.

The following interesting case is quoted from the 'Justice of the Peace,' December 21, 1904.

135. King's Bench Division, May 16, 17, 1904. Friend *v.* Mapp.

Sale of food and drugs—Adulteration—Sulphate of copper used to colour preserved peas—Sale to the prejudice of a purchaser—Sale of Food and Drugs Act, 1875 (38 & 39 Vict. c. 63), s. 6.

The respondent was summoned for selling preserved peas the colour of which had been retained by the addition of sulphate of copper, but in such small quantity as not to be injurious to health, and evidence was given that preserved peas are habitually sold with such addition. The Justices dismissed the summons. Held, *that the decision was justifiable on the facts of the case.*

Case stated by Justices of the Peace for the county of London, acting in and for the Kensington Petty Sessional Division of the said county:

1. The respondent was summoned for unlawfully selling to the prejudice of the purchaser an article of food, to wit, preserved peas (sample No. 75), which was not of the nature, substance, and quality of the article demanded by such purchaser, for the reason that the same contained, as stated in the certificate of the public analyst for the said borough, 0·00924 per centum of copper, equivalent to 2·55 grains per pound of crystallized sulphate of copper, contrary to the provisions of section 6 of the Sale of Food and Drugs Act, 1875.

4. The appellant called evidence to prove that copper was not a normal constituent of peas or of the human body. That a medicinal dose of sulphate of copper was from ¼ to 2 grains, and acts as an astringent. That in large doses sulphate of

copper acts as an irritant, and is apt to produce vomiting, and is a cumulative poison. That its occasional consumption in such a quantity as had been found in the said peas would not harm a healthy individual, but that habitual consumption thereof might injuriously affect the health and produce chronic ill health, and that copper is added to preserve peas, to give them a fresh bright green colour; but the appellant's witness admitted that such peas had been generally used for some years, and that he knew of no recorded case of injury arising from their use.

5. No evidence was called by the respondent, and the correctness of the analyst's certificate was not disputed.

6. The appellant contended (1) that inasmuch as copper or crystallized sulphate of copper was foreign to the said preserved peas, the same were not of the nature, substance, and quality of the article demanded; and (2) that by reason thereof there had been a sale by the respondent to the prejudice of the purchaser; and (3) that the addition of copper or crystallized sulphate of copper in the proportion aforesaid was injurious to health; and (4) that in the absence of evidence by the respondent that the matter or ingredient was required for the production or preparation of the peas as an article of commerce in a state fit for consumption, even if the said copper or crystallized sulphate of copper was not injurious to health, an offence had been committed under section 6 of the Sale of Food and Drugs Act, 1875.

7. It was contended on behalf of the respondent that, as the purchaser asked for preserved peas, and was supplied with peas usually known and sold as preserved peas, there was no sale to the prejudice of the purchaser within the meaning of the Sale of Food and Drugs Act, 1875.

8. It was within our own knowledge that preserved peas usually contain a small quantity of added colouring matter which is used for the purpose of preserving the natural green colour of the peas, and we found as a fact that the quantity of copper present in this instance, being only 1 grain of metallic copper

to about 10,800 grains of peas, was not sufficient to render the peas injurious to health. We were further of opinion that, as the appellant asked for preserved peas, and was supplied with peas usually known and sold as preserved peas, and containing no foreign ingredient other than that which is usually found in preserved peas, and in no greater quantity than as aforesaid, there was no sale to the prejudice of the purchaser within the meaning of section 6 of the Sale of Food and Drugs Act, 1875.

The summons was dismissed.

9. The question for the opinion of the Court was whether, upon the facts stated we were right in point of law in dismissing the summons.

Manisty, K.C., and Courthope Munroe, for the appellant.—The Justices were wrong. He cited Smith *v.* Wisden (1902), 66 J.P. 150; 85 L.T. 760.

Bonsey for the respondent.

Manisty, K.C., in reply, referred to Pearks *v.* Ward [1902], 2 K.B. 1; 64 J.P. 774; and Roberts *v.* Egerton (1874), L.R. 9 Q.B. 494.

Alverstone, L.C.J.—I am of opinion that in this case we cannot interfere with the decision of the Justices; but it must be quite understood that we are only dealing with the facts stated in this particular case, and that we express no opinion as to the views which ought to be taken by Justices in cases where the evidence is different; nor must it be considered that we express any opinion as to what conclusion should have been drawn from the facts even as stated here. We must be satisfied, before we can interfere, that there has been some mistake in law, and it appears to me impossible to say that in the case before us the Justices have gone wrong in law. The case contains no statement which can admit of the point counsel for the appellant has endeavoured to raise, which in itself would be a point of substance, that when a person asks for a bottle of preserved peas he means to get a bottle of peas which have not been treated in any manner for the purpose of preserving them. If it can be said that preserved peas mean

nothing more than mere peas in a bottle with water perhaps, and nothing else, there might indeed be some ground for such a contention, but the finding of fact in the case does not allow of such a point being raised. The finding in paragraph 3 (a) of the case is that 'the purchaser asked for and was served with a bottle of preserved peas'; and in paragraph 4 that 'the appellant's witness admitted that such peas have been generally used for some years, and that he knew of no recorded case of injury arising from their use.' Furthermore, the Justices in paragraph 8 make the following statement: 'It was within our own knowledge that preserved peas usually contain a small quantity of added colouring matter which is used for the purpose of preserving the natural green colour of the peas'; and 'the appellant . . . was supplied with peas usually known and sold as preserved peas, and containing no foreign ingredient other than that which is usually found in preserved peas, and in no greater quantity than as aforesaid,' namely, '1 grain of metallic copper to about 10,800 grains of peas.' Under these circumstances it seems to me that a great many of the arguments put forward by counsel for the appellant would be very properly used in some other case to induce Justices to come to a different conclusion of fact, or, on a case stated differently from the present case, to show that an offence had been committed, but in our opinion we cannot send this case back to them. Here the very finding of the Justices prevents the case coming within the initial words of section 6 of the Sale of Food and Drugs Act, 1875, which are: 'No person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance, and quality of the article demanded by such purchaser.' Had the appellant, the purchaser in the present case, not got what he asked for, I should have been of opinion that neither proviso (1) nor proviso (4) of section 6 would have afforded any protection to the seller; since to justify the supply of an article different from that demanded under any of the provisos to section 6, evidence of a character entirely different from the

evidence suggested in this case must be given. I should like to point out that, so far as we are in a position to judge, the appellant's real remedy in this particular case would have been under section 3 of the Act, which prohibits the colouring of articles of food so as to render them injurious to health. But, as I have said before, to satisfy section 6 evidence very different from that given in the present case must be given; and the only possible thing we could do would be to send it back to the Justices for further inquiry; but as we certainly cannot send it back to them with a direction to convict, and since we cannot say that the Justices were wrong in law, I am of opinion that the appeal must be dismissed.

Wills, J.—I am of the same opinion. It is clear that the protection afforded by provisos (1) and (4) of section 6 cannot be claimed, for the substantive part of section 6 goes far beyond the provisos. I should certainly be sorry to say anything which would sanction the notion that people can sell unwholesome mixtures simply because they happen to be known in the trade by a particular name; but when anyone asks for preserved peas he must be taken to know that he is going to get peas that have a colouring tincture of some sort. I am not prepared to say that in the present case I should, upon the evidence, have come to the conclusion the Justices did, but that is beside the question, for it was well within their powers to decide as they did, and, to put the matter shortly, they have stated the appellant out of Court.

Kennedy, J.—I agree. *Appeal dismissed.*

Solicitors for the appellant: Pontifex, Hewitt and Pitt.

Solicitors for the respondent: Neve, Beck and Kirby.

IV.—Unsound Food

136. Canned French beans. At the Brighton Police Court, January 1901, a firm of Soho provision importers were convicted for selling tins of French beans unfit for food. In all there were six cases, containing twenty-four dozen tins. Some of them were bulged, some leaking, and in 247 instances the tins

had been pricked and resoldered. In many cases the contents were mildewy and foul. At the London premises a piercing iron, copper bit, and solder, had been found by the Sanitary Inspector of the City of Westminster at a previous visit. The tins were sold to a restaurant-keeper at Brighton.

137. Mouldy jam and fruit, and unsound condensed milk. At the Folkestone Police Court, May 1901, a dealer was summoned for exposing for sale in an auctioneer's sale-room thirty-four pots of jam, ten bottles of plums, one bottle of gooseberries, and six tins of condensed milk, which were unfit for food. The Sanitary Inspector deposed to having seen the foods deposited in the sale-room for the purpose of sale and exposed for sale. The pots of jam were mouldy, fermenting, and sour, the plums and gooseberries being in a similar condition. He examined about forty tins of condensed milk, and four of them were blown and decomposing. Two of the tins were open, and the contents decomposing and mouldy. The Medical Officer of Health said he examined the articles. Four of the tins of milk were blown, and when one of them was pricked the gas rushed out. Such food if eaten would give rise to indigestion and diarrhœa. For the defence it was submitted that people had a right to eat what they liked, and that jam frequently crystallized and mould formed on the top, the jam beneath remaining quite wholesome. The same applied to the bottled fruit. Convicted.

138. Unsound fruit pulp. At the Birmingham Police Court, January 1904, a jam maker was convicted for having twenty-four bottles of preserved fruit and several casks of fruit pulp deposited on his premises for the purposes of sale, or of preparation for sale, which were unsound and unfit for food. Behind a door in the yard there was a cask containing gooseberry pulp. It was about two-thirds full of decomposed pulp, but was labelled 'not to be used.' Other casks containing similarly unsound pulp were likewise labelled. There were, however, three unopened casks of pulp, and twenty-four bottles of fruit, the contents of all being bad and in a state of

decomposition. The Medical Officer of Health deposed to having examined the fruit and found it bad; there were pieces of fungus in it. Jam made from such material would be dangerous to the consumer. For the defence it was contended that the pulp was not intended for use, but that the labels 'not to be used' had been washed off by rain.

139. Bad crabs. At Yarmouth Police Court, October 1901, a restaurant proprietor was summoned for exposing for sale crabs unfit for food. For the defence it was contended that it was the practice of the trade to open the crabs before selling them to ascertain if they were sound, but that the public would not buy them if previously opened. Convicted.

140. Unsound halibut. At the Grimsby Police Court, March 1903, a fish merchant was summoned for exposing for sale eleven unsound halibuts; a twelfth fish appeared to be sound. The fish were condemned by a Magistrate and destroyed. For the defence it was contended that the fish were not bad, but were Norwegian halibut in prime condition; others of the same batch had been sent to various towns and no complaint had been made. The defendant was supported by the fish Inspector of the Hull market.

The Bench considered the weight of evidence to be in favour of the defendant, and dismissed the case.

141. Oysters. At the Mansion House Police Court, December 1903, application was made under the Public Health (London) Act for an order to condemn certain oysters as being unfit for food. The Sanitary Inspector stated that he had seized 100 oysters at a fish saleswoman's shop, they having been exposed for sale in a barrel. Ten days previously the Medical Officer of Health for Wandsworth had reported to the Medical Officer of Health for the City of London that a case of typhoid fever had occurred in his district, which had presumably arisen from the consumption of oysters derived from the same source as those seized. Two batches of these oysters had in the meantime been procured and examined bacteriologically, and had been pronounced to be polluted by sewage. The oysters

were therefore seized by the Inspector, and the application was made in order that they might be examined too. The application was granted, on the understanding that any further sale of these oysters would be at the seller's risk.

142. The following cases under the Public Health Acts, recently decided in the High Court, and having reference to diseased meat, are of great importance to all concerned in the inspection of articles of food.

Firth *v.* MacPhail, King's Bench Division, April 3, 1905. (J.P. 69, p. 203.) Cow slaughtered to 'save its life' after parturition and sepsis. Bought with knowledge by appellant (a middleman), and consigned to a meat salesman, and deposited by appellant on salesman's premises.

Consignor summoned and convicted in Court of Summary Jurisdiction under Public Health Acts Amendment Act, 1890, section 28, as being the person to whom the cow did belong when deposited for the purpose of sale. Case stated. Held that appellant could not be subjected to the penalties under section 117 of the 1875 Act since the meat was not exposed for sale, and that the amending section only increased the scope of the articles which could be seized and condemned, and did not create a new offence.

143. High Court of Justice. Queen's Bench Division. June 6, 1899. A. L. Smith, L.J., Rigby, L.J., and Vaughan Williams, L.J.

Walshaw *v.* Brighouse Corporation. Local Government —Condemnation of meat unfit for food of man—Compensation —Arbitration—Jurisdiction of arbitrator—Cost of magisterial proceedings—Public Health Act, 1875 (38 & 39 Vic., cap. 55), sections 116, 117 and 308.

Where meat has been condemned and ordered to be destroyed by a Magistrate as unfit for the food of man, and the owner of the meat claims compensation under section 308 of the Public Health Act, 1875, the arbitrator appointed to award compensation under that section has jurisdiction to decide the question of the soundness of the meat, and may award as part of the

compensation the expenses incurred by the claimant in proceedings before the Magistrate.

Appeal by the defendants from a judgment of Day, J., without a jury. The facts were these: The Sanitary Inspector and the Medical Officer of Health for the district of Brighouse, acting under section 116 of the Public Health Act, 1875, inspected a carcass belonging to the plaintiff, which had been deposited at the public slaughter-house at Brighouse for the purpose of preparation for sale, and was intended for the food of man, and came to the conclusion that the carcass was diseased and unfit for the food of man. They thereupon showed it to a Justice of the Peace, who on October 19, 1897, upon examination and inspection, found that the carcass was diseased and unfit for the food of man, and acting under section 117 of the Public Health Act, 1875, and section 28, sub-section 2, of the Public Health (A.) Act, 1890, ordered it to be destroyed, and it was destroyed accordingly. A summons was then issued summoning the plaintiff to appear before a court of summary jurisdiction to answer an information laid by the Medical Officer to the effect that the carcass belonged to the plaintiff and was deposited for the purpose of preparation for sale, and was intended for the food of man, and was diseased, and to show cause why he should not be fined or imprisoned under section 117 of the Public Health Act, 1875. This summons was dismissed upon the ground that, as the carcass was not in the possession of the plaintiff, or exposed for sale, there was no offence under that section. No order was made by the Justices as to costs, and no further proceedings were taken against the plaintiff.

The plaintiff, not being content with the finding of the Magistrate that the carcass was diseased and unfit for the food of man, made a claim against the defendants, the local authority, for damage sustained by him by reason of the exercise by them through their officers of their powers under sections 116 and 117 of the Public Health Act, 1875, in certifying that the carcass was diseased, and having the same condemned and destroyed

accordingly. The defendants disputing the fact of damage and the amount of compensation (if any) to be paid, the plaintiff appointed an arbitrator under sections 308 and 179 of the Public Health Act, 1875, and gave notice to the defendants of the appointment. The defendants took no steps in the matter, and accordingly by section 180 of the Public Health Act, 1875, the arbitrator appointed by the plaintiff became sole arbitrator between the parties. At the hearing the plaintiff tendered, and the arbitrator, overruling the defendants' objections, admitted, evidence that the carcass was sound, wholesome, and in every way fit for the food of man on October 19.

The arbitrator in due course made his award, which, after reciting the facts above stated, continued in these words:

'I find as facts: 1. That the seizure and condemnation of the said carcass was made. . . . 2. That the said magisterial information was laid and dismissed as alleged. 3. That the said carcass was not diseased, or unsound, or unwholesome, or unfit for the food of man on the said 19th day of October, 1897, when the said order to destroy the same was made. 4. That the said carcass on the 19th day of October, 1897, when the same was ordered to be destroyed as aforesaid, was sound, wholesome, and fit for the food of man. 5. That the said David Walshaw, by reason of the exercise of the said powers, has sustained damages as follows:

	£	s.	d.
(a) The loss of the said carcass	7	10	0
(b) Expenses of and incident to the said seizure, and of and incident to defending himself in the said magisterial proceedings	37	1	0
(c) Loss in his said business which immediately and necessarily flowed from the said seizure, condemnation, and magisterial proceedings . .	52	0	0
Total	96	11	0

The arbitrator further ordered and directed that the defendants should pay to the plaintiff his costs of and incidental to the reference and costs of the award, and that the defendants should bear their own costs of the same.

The plaintiff brought an action upon this award, and the

case was heard at Leeds before Day, J., without a jury. Evidence that the carcass was unsound and unfit for the food of man was tendered by the defendants, but rejected by the learned Judge, who gave judgment for the plaintiff.

The defendants appealed.

Macmorran, Q.C., and T. R. D. Wright appeared for the defendants. Scott Fox, Q.C., W. J. Waugh, W. Madden and G. P. Walker, for the plaintiff, were not called upon.

A. L. Smith, L.J.: The arbitrator has drawn his award in the right form. It is not in form a decision on the question of the appellants' liability, but is a finding of facts upon which a court of law may decide that question. By section 308 of the Public Health Act, 1875, 'Where any person sustains any damage by reason of the exercise of any of the powers of this Act in relation to any matter as to which he is not himself in default'—the respondent says he has suffered such damage—'full compensation shall be made to such person by the local authority exercising such powers'—I will deal with the compensation presently—'and any dispute as to the fact of damage or amount of compensation shall be settled by arbitration.' What is the meaning of 'the fact of damage'? These words have been construed by Lord Selborne and Lord Fitzgerald in Brierley Hill Local Board *v.* Pearsall. Lord Selborne there says, 'That matter of fact no doubt cannot be ascertained without dealing with the actual state of facts, whatever it may be found to be; and that actual state of facts may possibly raise questions of law as to what is or what is not done properly' in the exercise of any of the powers of the Act, 'and also as to what is and what is not a default on the part of the claimant. But the inquiry does not cease to be an inquiry into the facts though the facts may raise questions of law. If the arbitrator goes into the inquiry, as he ought, as a question of fact, and if he deals with the facts as he finds them, but deals with them in a wrong view of those facts according to law, then no doubt his award will not be final.' But it is not suggested that the arbitrator in this case has dealt with the

facts in any wrong view. Then Lord Fitzgerald says, 'In establishing his case under that section'—section 308—'the plaintiff has to sustain four propositions, viz. first, that he had sustained damage; secondly, that such damage had been occasioned by reason of the exercise of the local authority of the powers of the Act; thirdly, that such damage arose in relation to some matter as to which he was not himself in default; and fourthly, the amount of compensation to which he was properly entitled. Any dispute as to propositions 1 and 4 is to be settled by arbitration. The fact of damage comes first in the section, and it is the foundation of all the rest. In the execution of his duties it is difficult to see how the arbitrator can avoid inquiring whether the acts complained of were matters done in the exercise of the powers of the Act, and as to which the claimant was not himself in default, so as to limit the scope of his assessment of compensation; but his decision, if any, as to the liability of the defendants in point of law would not be binding, and would be inoperative.'

If the award involves an error in law it is open to the party sued upon the award to set up the question of law as a defence to the action. Here the arbitrator finds that in exercise of and accordance with, or pretended exercise or virtue of, the powers and provisions of the Public Health Act, 1875, the defendants by their officer on October 19, 1897, seized the carcass and caused the same to be condemned by a Justice of the Peace; and that the carcass was not diseased, or unsound, or unwholesome, or unfit for the food of man, on October 19 when the order to destroy the same was made. It is said that he ought not to have gone into the question of the soundness of the meat. But how otherwise could he find the fact of damage? In order to find that fact he must go into the question of the soundness. Then it is said he has not addressed himself to the question whether the claim for compensation was in relation to a matter as to which the claimant was not himself in default. But if the carcass was sound, how was the claimant in default? It is argued that he was in default immediately

on the finding by the Magistrate that the carcass was unsound. But unless it was unsound in fact, he never came within sections 116 and 117 at all.

The plaintiff having thus lost the carcass and been put to expense, it is next contended that the damage was not caused through the act of the defendants. But it was all the result of a blunder by their officer acting in the course of his duty. Then it is said that he cannot recover the 37*l.* 1*s.*, the expenses of the proceedings. I ask myself 'Why not?' The words of section 308 are 'full compensation shall be made.' The only question is, had the plaintiff 37*l.* 1*s.* less in pocket through the action of the local authority? It is said that these expenses are costs; but Bater and Birkenhead Corporation, *In re*, is an authority that they may be recovered notwithstanding. True, in that case the claimant for compensation appeared before the Justice to show cause why the meat should not be condemned; but what difference does it make whether the expense is incurred before or after condemnation? In the words of Lord Esher, M.R., 'We are bound to read section 308 in its ordinary and grammatical sense. The words used are very wide, and it seems to me that they must include any pecuniary loss which a man suffers when he is not himself in default.' I think these are expenses for the payment of which the respondent was entitled to full compensation, and this appeal must be dismissed.

Rigby, L.J., and Vaughan Williams, L.J., concurred.

144. High Court of Justice, Queen's Bench Division.

Before Ridley and Bigham, JJ. May 16, 1900.

A Magistrate acting under section 47 of the Public Health (London) Act, 1891, must decide whether any article of food is unsound or unwholesome or unfit for food of man, but the question whether the goods are exposed for sale is not one for the Magistrates but for the Medical Officer of Health.

Thomas *v.* Van Os.

This was an appeal by way of a special case from the decision of the Magistrate sitting at the Thames Police Court, the question raised being whether, before a Magistrate acting

under section 47 of the Public Health (London) Act, 1891, condemns an article as being unsound or unwholesome, or unfit for the food of man, it is necessary that the Magistrate should have before him evidence that the goods were intended for the food of man. In July of last year an application was made to the Magistrate to condemn 117 tubs of strawberries. The Magistrate refused the application on the ground that there was no evidence before him that the strawberries were intended for the food of man. A rule *nisi* was then obtained directing him to state a case, and this rule was made absolute on January 11, 1900.

From the case as stated the following facts appeared:

The appellant was the Medical Officer of Health for the district of Limehouse. On July 17, 1899, he saw a van in Devonport Street, Ratcliffe, containing the fruit, which upon examination he found to be unsound and unwholesome, and unfit for the food of man. The strawberries were sent to the defendant from Holland under contract with one Van Namen, and on arrival in London the defendant had ordered a carman to convey them to Messrs. John Moir, Limited, of Brook Street, Ratcliffe, who on seeing them refused to take them. The defendant admitted that the strawberries were unfit for the food of man. The Medical Officer of Health, acting under section 47 of the Public Health (London) Act, 1891, caused them to be brought before the Magistrate, who refused to condemn them on the ground that there was no evidence that the fruit was intended for the food of man, or sold, or exposed for sale, or deposited for the purpose of sale at the time of the seizure. He held that when Messrs. John Moir refused to take the fruit any intention of applying them for the purposes of food or sale was exhausted. In the absence of such evidence he held that he had no jurisdiction to make any order of condemnation.

R. D. Muir, for the appellant, contended that there was ample evidence that the strawberries were intended for the food of man, being deposited in a van for the purpose of sale; that the defendant was unaware that Messrs. John Moir had

refused them, and that the intention to sell continued after such refusal. He further argued that the question whether the goods were exposed for sale was not one for the Magistrate, but for the Medical Officer of Health. He cited White *v.* Redfern (5 Q.B.D., 15); Vintner *v.* Hind (10 Q.B.D., 63); *In re* Bater and Birkenhead Corporation (1893, 2 Q.B., 77).

Ridley, J., in giving judgment, said that section 47 of the Act defined the powers of the Medical Officer of Health. He might enter upon the premises of the defendant and inspect and examine any article intended for the food of man. It was obvious that as a preliminary to putting his powers in force the Medical Officer of Health must make up his mind whether the articles examined came within the description in section 47—that is, whether they were intended for the food of man or exposed for sale. Having made up his mind on that question his duty was to examine the articles. If he found them unsound or unwholesome, or unfit for the food of man, then, and not till then, the functions of the Magistrate came into operation. The Magistrate must then decide whether the articles were in fact unsound, unwholesome, or unfit for the food of man, and having decided that, his further duties were merely ministerial. The question whether the articles were intended for the food of man was, at this stage of the proceedings, immaterial, and did not become material until sub-section 2 of section 47 came into operation, and the person exposing the goods for sale was charged on summons for an offence under the Act. The case of White *v.* Redfern (5 Q.B.D., 15) was properly decided, and covered this case in principle.

Bigham, J., concurring, the case was remitted to the Magistrate, with an intimation that the strawberries ought to have been condemned.

Appeal allowed.

145. Shutt *v.* Stockton Corporation. January 28, 1901.

Before Mr. Charles Mellor (umpire) and Messrs. C. H. M. Wharton and A. W. Bairstow (arbitrators).

In arbitration—Public Health Act, 1875, section 308.

On January 28, 1901, Mr. Charles Mellor, barrister, sat as umpire with Mr. C. H. M. Wharton, barrister (Manchester) as arbitrator for the Corporation, and Mr. A. W. Bairstow, barrister (Leeds) as arbitrator for the claimant, to hear and decide a claim for damages by Mr. Langle Shutt, Stockton and West Hartlepool, for 49*l*. 13*s*. 11*d*., against the Stockton Corporation in respect of the seizure of a carcass of beef alleged to be unfit for human food, which the claimant denied was unsound. Mr. Langley appeared for the claimant, and Mr. Luck, barrister, Darlington (instructed by the Town Clerk), for the Corporation.

Mr. Langley said that the claim for compensation was under section 308 of the Public Health Act, 1875, on the grounds: (1) That the carcass was a perfectly healthy one; (2) that the seizure was illegal being made by the Assistant Inspector; and (3) that the Corporation had not allowed sufficient time for the carcass to be examined by experts. On behalf of Mr. Shutt, he asked for 49*l*. 13*s*. 11*d*., damages, being 12*l*. 3*s*. 11*d*. cost of beast, and 37*l*. 10*s*. in respect of consequent loss of business in the nine months that had since elapsed.

The details of the case were as follows: On Thursday morning, April 5, 1900, Mr. Thomas W. Agar, the Assistant Inspector of Nuisances, visited the claimant's slaughter-house, and in it found what he considered a graped carcass of beef, the condition of which was thus described by Dr. Horne (the Medical Officer of Health) and the Assistant Inspector: The midriff had been removed with the exception of a narrow strip attached to the ribs on each side, and known as the 'skirting.' The off-side skirting measured 16 inches by $2\frac{5}{8}$ inches, and its abdominal surface was covered for 20 square inches with tubercles from $\frac{1}{16}$ inch to $\frac{1}{4}$ inch in diameter. On the adjacent parietal peritoneum was an oval area, 28 square inches in extent, of inflammation, with numerous tubercles. The near-side skirting exhibited a similar tuberculous area of 12 square inches, with an inflamed tuberculous patch, 10 square inches

in extent, on the adjacent parietal peritoneum. The mesenteric glands were enlarged and tuberculous, and the tripe was inflamed and covered with numerous tubercles. The liver and kidneys were not examined, having been taken away to West Hartlepool. Both lungs were affected with miliary tuberculosis, and were congested at the apices, and the bronchial glands were enlarged and tuberculosed.

The Assistant Inspector told the slaughterman that the Medical Officer of Health would have to see the carcass, and refused to allow the lungs to be destroyed and the rest to pass. Later in the day the owner inquired at the office what was to be done with the carcass, and asked the Assistant Inspector, (Mr. Agar) why he had reported the case to the Medical Officer of Health, and not to his (Agar's) master, meaning Mr. Crowther, the Chief Inspector, 'because Mr. Crowther knows as much about meat as any doctor.' Agar replied that Mr. Crowther was not his master, and had nothing to do with the case. The same afternoon, by direction of the Medical Officer of Health, the Chief Inspector (Mr. Crowther) examined the carcass and said to the owner: 'This is the finest beast you have had since Christmas and the best nourished,' and reported in writing to the Medical Officer of Health as follows:

'The body itself is good solid beef, and firm to the touch; on the open and closed side of the abdomen, and above the diaphragm, are small patches of inflammation, with a few tubercles forming on the outer surface. The heart is in a good healthy condition, lungs slightly congested at apex, with tubercles scattered over surface; kidney in healthy condition: tripe had inflamed surface. There was no liver.'

At 9.45 A.M. on Friday, April 6, the Medical Officer examined the carcass, &c., pronounced it unsound and unfit for food, and instructed the Inspector to carefully measure up the affected parts, and to get a Magistrate's order for destruction, which was done about 3 P.M., the order being made out in the name of Mr. Agar, the Assistant Inspector. Subsequently the Medical Officer of Health instructed him to let the carcass

remain till seen by the Butchers' Association's inspectors. At 10 A.M. on Saturday, April 7, the Assistant Inspector called at the slaughter-house, and found that a strip two-thirds of the length of the off-side skirting and about ¾ inch wide had been cut away, together with the tubercles, &c., upon it; also that structures round the windpipe, close to the apex of the lungs, had been removed. He reported the matter to the Medical Officer of Health, who, after conference with the Town Clerk, ordered him about noon on April 7, to take away and destroy the carcass, which he then did.

The facts were subsequently discussed by the Sanitary Committee and the Town Council, and a minute was recorded on May 14, 1900, that the carcass was unfit for food, but that no further steps be taken in the matter.

In support of his claim, Mr. L. Shutt stated that the animal in question 'was a very grand young beast'—it was the second best of four, for which he paid 12*l.* 10*s.* each. It looked very healthy, and ate and drank well; the flesh was not soft and flabby, and there were no signs of tuberculosis. He gave evidence as to his subsequent loss of business, but admitted he kept no books. J. Hutchinson (slaughterman), Messrs. Thomas Robinson, Councillor John Borrow (butcher), and William Ayre (meat-salesman) also stated that there were no signs whatever of tuberculosis, but each had noticed a slight discoloration of the skirting on one side, the result of a bruise.

Mr. John Brand, butcher, said he was a member of the Meat Trades Association, and had laid the facts before the Federation. The carcass was of good quality, firm and bright, there was no sign of tubercle, and it was quite fit for food. One lung was slightly knotty, which might have been due to cold or it might be from tuberculosis. The discoloration on the diaphragm was a blood-stain which had 'run down and dried in,' and might have been caused by concussion producing internal injury. He had a key of the slaughter-house during the alleged tampering, and denied that it had taken place.

Agar told him that the slaughterman had another key. He asked Agar (the Assistant Inspector) to have a portion of the diaphragm put into spirits, but he refused. For the Corporation it was asserted that the animal was suffering from generalized tuberculosis, that the seizure was justified and regular, the Assistant Inspector having acted under the orders of the Medical Officer of Health, as his assistant, and that the claimant had sufficient opportunity to obtain expert evidence had he desired to do so, and would have had still longer if the carcass had not been tampered with.

Mr. Thomas W. Agar stated that he was appointed in January 1899, Inspector of Nuisances for the east district of the town, to act under the direction of the Chief Inspector. On February 13, 1899, a resolution was passed by the Sanitary Committee that both the Assistant and the Chief Inspectors were to act under the directions of the Medical Officer of Health. He had received no intimation that this latter resolution had never been confirmed. He never consulted Crowther. He testified in detail to the condition and seizure of the carcass as above described, and to his conversations with the owner and his representatives. Dr. Horne elaborated the Inspector's description, and said it was a case of generalized tuberculosis. He was positive that there was miliary tuberculosis of both lungs, and there were tuberculous lesions on both the pleura and peritoneum. Either of these conditions rendered the carcass unfit for food. He asked to see the liver, as it corresponded in position to the larger inflamed patch on the diaphragm, but was told it had been sold. He was asked whether his relations with the Chief Inspector (Mr. Crowther) were strained, but Mr. Wharton (arbitrator) did not see how that affected the case. Mr. Crowther had told him that he would not condemn the carcass.

Mr. W. C. Crowther, the Chief Inspector, said he had had fifteen years' experience, and had examined all the cases until Mr. Agar came. At Dr. Horne's request he carefully examined this carcass on Friday, April 6. He considered it fit for

human food, and told the Sanitary Committee he would not have condemned it. He had read the recommendation of the Royal Commission, and did not consider that, tested by these recommendations, his written report to the Medical Officer in itself furnished sufficient grounds for condemnation.

Several Medical Officers of Health gave evidence in support of Dr. Horne's views, and on February 11 the arbitrators decided: 'That the claimant was in default in respect of the carcass, and suffered no damage from its destruction, that the carcass was unsound, and unfit for the food of man, and was, in consequence, properly and lawfully destroyed.' The claimant was ordered to pay the costs of the award, and the arbitrators' and umpire's fees, and 20*l.* to the Corporation on account of their costs.

146. Important decision under Sale of Goods Act, 1893.[1] High Court of Justice. Court of Appeal, February 1905. Infected milk. Frost *v.* Aylesbury Dairy Co.

'*When milk is sold by a dairy company for consumption as food there is an implied warranty on the part of the vendors that it is reasonably fit for that purpose, and they will be held liable for damages caused by reason of its being infected, although such infection was latent and not discoverable by ordinary care and skill.*

'This was an appeal by the defendants, asking for a new trial or judgment in an action tried before Grantham, J., and a special jury. The action was brought by the plaintiff to recover damages owing to the illness and death of his wife from typhoid fever, caused, as he alleged, by the milk which was supplied to him by the defendants being contaminated with the germs of typhoid fever. The jury found a verdict for the plaintiff for 106*l.*, the expenses to which the plaintiff had been put in consequence of the illness and death of his wife, and judgment was entered for him accordingly.

'MacMorran, K.C., and W. Mackenzie appeared for the defendants, and contended that under section 14 (1) of the

[1] *Public Health*, April 1905.

Sale of Goods Act, 1893, the defendants did not impliedly warrant that the milk was free from infection, as no care and skill on their part could have discovered whether it was infected or not. They also contended that the verdict was against the weight of the evidence, and that the Judge at the trial had misdirected the jury, and introduced topics of prejudice against the defendants.

'Duke, K.C., and Holman Gregory, for the plaintiff, were not called upon, and the Court dismissed the appeal.

'The Master of the Rolls said that the first point taken was that, admitting that the milk was the cause of the typhoid fever, upon the facts of the case there was no actionable wrong on the part of the defendants. The question was whether, in the particular circumstances, the case had been brought within section 14, sub-section 1, of the Sale of Goods Act, 1893. It was said that the buyer had not made known to the seller the particular purpose for which the goods were required, so as to show that he relied on the seller's skill or judgment. They had not evidence in any precise detail of the inception of the relationship between the plaintiff and the defendants. They began with the fact that the plaintiff was dealing with the defendants. The result was that milk was purchased by the plaintiff from the defendants. That involved a contract for the supply of an article of food, namely, milk. The purpose for which the milk was supplied was obviously for consumption as an article of food. It did not require any evidence to prove the particular purpose for which the milk was supplied. The jury must be taken to have found that. Where was the condition so as to show that the buyer relied on the seller's skill or judgment fulfilled? If any seller ever did inform the mind of a buyer of his special care as a seller, as an inducement to the would-be buyer to deal with him, those defendants did. The book, which had been called the pass-book, which was supplied to the plaintiff, was full of particulars of their skill and knowledge in the matter. It contained paragraphs headed "Milk in relation to Tuberculosis and other Diseases," stating the precautions taken to ensure that only pure milk,

free from all germs of disease and free from adulteration, was supplied. One paragraph related to "medical inspection," another to "milk analysis," another to "veterinary surgeon." The buyer could not escape being permeated with the sense that he was secured against the possibility of danger if he bought the defendants' milk. Milk, therefore, for the supply of the plaintiff and his family was tendered by a seller with all his knowledge and skill. It was then said that the buyer could not rely upon the seller's skill or judgment in a case where no skill or judgment could have found out the defect. That was a contention that a person could not become liable for an undiscoverable latent defect. The law upon the point was the same now as it was at Common Law before the Sale of Goods Act, 1893. That point had been dealt with and decided by the Court of Appeal in Randall v. Newson (2 Q.B.D. 102), where it was held that on the sale of an article for a specific purpose there was a warranty by the vendor that it was presumably fit for that purpose, and that there was no exception as to latent undiscoverable defects. Then, with regard to the alleged misdirection, it was a well-established rule that, even if there was misdirection, still, if that misdirection did not affect the result of the trial, the Court would not be justified in sending the case down for a new trial. The case must therefore be dismissed. Lord Justice Mathew delivered judgment to the same effect, in the course of which he said that there was no reason whatever for any reflection upon the defendant company. They had imposed stringent conditions upon the farmers from whom they obtained milk, but it was obviously impossible, where the milk was drawn from different parts of the country, to see that each farmer complied in every respect with their conditions and requirements. He (the Lord Justice) regretted that the use of the word "Aylesbury" in the name of the defendant company was reflected upon by the learned Judge. He desired to say that he did not concur in these reflections, and in his opinion the defendant company came well out of the inquiry.

'Lord Justice Cozens-Hardy agreed.'

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APPENDIX I

REPORT OF THE DEPARTMENTAL COMMITTEE APPOINTED TO INQUIRE INTO THE USE OF PRESERVATIVES AND COLOURING MATTERS IN THE PRESERVATION AND COLOURING OF FOODS

THE conclusions arrived at by this Committee are as follows:

1. 'The medical evidence, speaking generally, comprises for the most part opinion arrived at after a general consideration of the issues involved, but such opinion was not always based directly upon fact. The physiological evidence consists of the citation of the results of more or less exact physiological experiments. But, unfortunately, in the majority of cases the conditions under which the experiments have been made have only partially imitated those conditions which obtain in the actual taking of preservatives by the human subject of all ages for indefinite periods of time.

2. 'Further, even supposing that we were to assume that the physiological experiments which have been laid before us did imitate with sufficient exactness the actual conditions obtaining in the inquiry in point, they would certainly only do so in so far as relates to the use of one preservative during a given period of time. The facts, however, show that in ordinary life what actually occurs is the simultaneous ingestion of more than one preservative. A further condition, almost impossible of imitation by the physiological investigator, is the consumption of these preservatives by all classes of invalids and by sucklings. The absolute effect of these substances upon sucklings is at present unknown, and it is also practically impossible to infer with accuracy from facts at present ascertained what would be the effect of, for instance, formic aldehyde upon a patient suffering from uræmia.

3. 'A factor still more subtle in its influence upon the question before us is idiosyncrasy. Certain individuals are extremely sensitive to certain drugs, and it appears that among these drugs must be reckoned at least one of the agents used as a preservative. Although legislation covering all possible idiosyncrasies would be too complicated to be practical, nevertheless, it must be pointed out that as

matters are at present, an individual possessing an idiosyncrasy with regard to the poisonous action of boracic acid would not be able to profit even by his own experience. For since the addition of this substance to food is not declared, he might be continually made ill by the repeated involuntary consumption of articles of food containing it.

4. 'The actual material upon which to base trustworthy conclusions has not existed heretofore, in that the declaration of preservatives, and also a regulation of, and notification of, the amount thereof present in any preserved food must be regarded as a necessary preliminary to any accurate observations or statistics upon the subject. Had declaration of preservatives been in force during recent years, we should probably now have been in possession of medical evidence more directly based upon fact than that which we have had laid before us.

5. 'Notwithstanding the fact that trustworthy data as to actual injury are but few, there is evidence pointing to the probability that such injury does at times accrue. We cannot overlook the danger to which the uncontrolled use of drugs in the food of the population may be likely to give rise.

6. 'Compounds of boracic acid have not been proved to be more hurtful than saltpetre to the consumer, yet saltpetre has been used from time immemorial in curing bacon, &c. The modern use of borax and boracic acid has enabled producers to dispense with a large proportion of common salt formerly necessary, thereby rendering bacon far milder to the palate, and protecting it from taint and fly-blow.

7. 'Although the greater number of the witnesses disclaimed any knowledge that boracic acid or borax is actually injected into the carcasses, we are convinced from our own observations as well as from the testimony of certain witnesses, that these preservatives are used in the curing of hog products, ham having been found to contain amounts varying from 4 to 24 grains per pound, and bacon from $2\frac{1}{2}$ to $8\frac{1}{2}$ grains per pound. The use of boron preservatives, which began about twenty years ago, is now very general in the import trade in bacon and ham. No doubt they are exceedingly convenient, but that they are not indispensable is proved by the success of a large and well-known firm of exporters of Wiltshire bacon, which uses no antiseptics but salt and saltpetre.

8. 'Concerning the physiological effects of the sulphites, a preservative often used by butchers, poultry dealers, and brewers, there has been no evidence laid before this Committee. It appears, how-

ever, that when sulphurous acid or its salts are added to organic compounds such as beer or butchers' meat, some is at once oxidized to sulphate, which may be regarded, at any rate in the amount present, as indifferent; some attaches itself chemically to certain constituents of the food in question, and the compound formed is also innocuous; a third portion remains as sulphurous acid, and it is this portion alone which is of permanent efficacy as an antiseptic. Concerning the effect of this moiety upon the consumer pharmacologists do not seem agreed, and further investigation is required before the sulphites can be regarded as either harmful or harmless.

9. 'After very carefully weighing the evidence we have come to the conclusion that, as regards the trade in fresh and cured meat, fish, butter, margarine and other food substances in the consumption of which but small quantities of the antiseptic are taken into the system, there exists no sufficient reason for interfering to prevent the use of boron preservatives. Even butter, of which the imports from all countries, except Denmark, frequently contain boracic acid, is not consumed in such quantities by individuals as to convey more than a very moderate daily amount of the drug into the system. The evidence satisfies us that the amount of preservative corresponding to 0·5 per cent. of boracic acid is sufficient for the purpose of preserving butter.

10. 'But the circumstances and considerations affecting the milk traffic are very different. Milk, a very perishable substance, peculiarly liable to bacterial contamination, forms a very large proportion of the daily food of the public. The nutrition of infants and young children depends greatly on the purity and abundance of the milk supply, and, seeing how frequently milk is prescribed for invalids and convalescents, it is of the utmost importance that it should not be the vehicle of any unsuspected agent. While it is possible that milk containing boracic acid in sufficient quantity to act as a preservative (say 30 grains to the gallon) might be consumed to the amount of 4 or 5 pints a day, without harmful results, by most healthy children or adults, there is evidence pointing to an injurious effect of boracized milk upon the health of very young children.

11. 'Moreover, there exists at present no guarantee against the addition of excessive amounts of preservative to milk. In 1896 the Medical Officer of Health for Birmingham estimated the amounts of boracic acid in a number of milk samples. Of these, one-half showed boracic acid in a proportion not exceeding 21 grains per gallon, in one fourth the proportion varied between 21 and 42 grains per gallon, while

in the remaining fourth it ranged from 42 up to 126 grains per gallon. Professor Blyth instances a sample of milk, purchased in Marylebone, containing boracic acid in the proportion of no less than 80 grains to the pint. This occurred in December 1899, and the witness assured us that from time to time he had found an equally high proportion in milk samples taken in summer.

12. 'Clearly such random use of any drug in a food calls for regulation. At present milk may be subjected to several successive treatments with preservative before it reaches the consumer. The farmer or producer sometimes applies it; so does the wholesale purveyor; so does the retail dealer; lastly, the domestic use of preservatives is increasing, and has become very general, and hence the milk may receive a fourth dose before it reaches the unsuspecting consumer.

13. 'There is this further objection to the use of preservatives in the milk traffic, that they may be relied on to protect those engaged therein against the immediate results of neglect of scrupulous cleanliness. Under the influence of these preservatives milk may be exposed without sensible injury to conditions which otherwise would render it unsaleable. It may remain sweet to taste and smell and yet have incorporated disease germs of various kinds, whereof the activity may be suspended for a time by the action of the preservative, but may be resumed before the milk is digested.

14. 'It has been put before us that it is not possible to supply large towns, especially London, with new milk without the aid of preservatives, but we have received abundant evidence to prove that this is no more than a matter of organization and system. No doubt the prohibition of preservatives in milk offered for sale would tend to the disadvantage of small retailers who have no cold storage, but this is not a consideration which should stand in the way of a much-needed reform.

'As to the feasibility of conducting the traffic in the largest towns without preservatives we have no doubt whatever. In Denmark the use of all preservatives in milk is strictly prohibited, and the prohibition is stringently enforced. Much of the milk consigned from the country to Copenhagen is conveyed in ice-wagons, or wagons otherwise specially adapted for the traffic, the property of purveying companies in the capital.

15. 'It has been estimated that about 50 per cent. of the dairymen of London use preservatives. One of the largest dairy companies in London (Welford Dairy Company, Ltd.) declined to furnish us with any information, but evidence was given by another large company (the Aylesbury Dairy Company, Ltd.) that they use no preservative whatever, either in milk, cream or butter.

16. 'Even more conclusive of the practicability of supplying the metropolis with milk unmixed with preservative was the evidence of Mr. T. Carrington Smith, who during a series of several years consigned milk to London from Mid-Staffordshire, a distance of 126 miles, under a contract which prohibited him from the use of preservatives. The milk was carefully strained and cooled by means of water, precautions which the witness pronounced indispensable, and there never was any trouble from the milk going sour. Mr. Smith, who appeared on behalf of the Royal Agricultural Society, handed in letters from farmers, sending the milk from 500 to 1,500 cows daily to London from Faringdon and Didcot without the use of preservatives.

17. 'In face of these facts we are of opinion that it is idle to pronounce it impossible to supply London with milk not artificially preserved. The business would be attended with some inconvenience at first, but we are impressed with the need for facing that inconvenience, and for rendering the vendors of milk containing preservatives subject to penalties under the Sale of Food and Drugs Act. Obviously the conditions under which milk is sometimes kept in the homes of the poor is likely to hasten the processes of decomposition, but we do not think this a sufficient argument in favour of the sale of chemically preservatized milk.

18. 'In regard to cream the question is somewhat different. We are of opinion that, under present conditions, it would be difficult to maintain or increase the present supply of cream without the use of some preserving agent. The presence of a preservative is less objectionable in cream than in milk, because cream is usually consumed in much smaller quantities than milk; but inasmuch as cream is now often prescribed for invalids and children instead of cod-liver oil, we consider that the obligation should be laid on the vendor of cream of notifying the presence, nature, and quantity of the preservative.

19. 'One of the considerations which render it expedient to prohibit the use of any preservative in milk offered for sale, namely, the large quantity which may be taken into the system of the consumer, places, in our opinion, wine, cider, and temperance beverages upon a very similar footing. Moreover, while by far the greater proportion of preservatives used in the dairy industry consists of compounds of boron, a substance without any active toxic properties, it is otherwise with fermented and temperance drinks. The usual preservatives in these articles are salicylic acid and formaldehyde, and although the quantity of each actually required is very small, it is often largely exceeded.

20. 'Thus the Public Analyst of Blackpool, Blackburn, &c., found

in sweetened lime-juice cordial, "consumed," as he said, "considerably at children's parties and such like festivities," amounts varying from 20 grains to 108 grains of salicylic acid per gallon. That the use of any preservative whatever in such drinks is unnecessary was proved to us by one of the largest manufacturers in this country, who stated that his firm never use them at all, although he considered that it would be convenient to do so.

21. 'As stated above, we have not given attention to the prevalence of preservatives in beer, that matter having been threshed out so recently before the Beer Materials Committee, but in the manufacture of cider we found that the employment of salicylic acid is very general, both in the native and imported article. While one cider manufacturer told us that he used no preservative, another strongly advocated the use of salicylic acid.

22. 'As regards wine, whether British or imported, we are of opinion that wine which cannot be made or kept without the use of a preservative had better not be offered for sale. We are confirmed in this view by the action of the Government of the chief wine-producing country in the world, namely, France, which by the law of January 11, 1891, absolutely prohibited the use in wine of all preservatives (except chloride of sodium or common salt to the extent of 1 gramme per litre), and of all colouring matters whatever.

23. 'In regard to the colouring matters of modern origin, while we are of opinion that articles of food are very much preferable in their natural colours, we are unable to see from the evidence received that any injurious results have been traced to their consumption. Undoubtedly some of the substances used to colour confectionery and sweetmeats are highly poisonous in themselves, but they are used in infinitesimal proportions, and before any individual had taken enough of colouring matter to injure him, his digestion would probably have been seriously disturbed by the substance which they were employed to adorn.

24. 'The employment of copper sulphate to colour peas and other vegetables has been carefully considered by us. It is highly undesirable that what is admittedly a poisonous substance should be used, even to the smallest extent, in connection with such food as may be consumed in considerable quantity. The public have got into their heads that vegetables ought to be green, and green they insist upon having them. Direct proof that vegetables containing copper are injurious to the consumer is from the nature of the case difficult to obtain, and we must admit that we have not succeeded in obtaining it. There is evidence pointing to the conclusion that the

copper, when added to the vegetables, forms a compound which is not easily soluble in the human economy. There is, however, evidence of a contrary character, and it is not clear to us that the whole of the copper added becomes, or remains, insoluble under all conditions. Be this as it may, recent events have so incontestably demonstrated the serious and widespread mischief which may result from the consumption of food and drink, other than sweetmeats, containing even minimal quantities of poisonous metallic substances, that we are strongly of opinion that such poisonous substances should be rigorously excluded.

25. 'There is such a wide choice of colouring matters suitable for the dairy trade, that no inconvenience would arise from restricting it to the use of innocuous substances as these may be defined and permitted in the manner hereafter suggested. But the same reason which we have given for the prohibition of preservative in milk offered for sale, namely, the large quantity thereof which may be consumed by an individual, appears to render it highly undesirable that any colouring matter should be permitted in milk. There is this further consideration, that milk is sold as an absolutely raw, unmanufactured article, of which the purchaser is entitled to be aware of the natural colour, and to draw his own conclusions therefrom as to quality.

26. 'In the butter trade, and still more so in the cheese trade, artificial colouring has long been established. Highly coloured goods find favour in some markets, uncoloured or faintly coloured goods in others. We have not found that in the interest of the consumer any interference is necessary with the customs of the trade in this respect.

27. 'In regard to margarine, we have to deal with a cheap and relatively inferior article invariably coloured to resemble a more costly and superior article, and probably the only means of protecting the public from imposition would be to prohibit the introduction of any colouring matter into margarine which shall cause it to resemble butter. Be the regulations as to the sale of margarine under declaration what they may, they cannot protect the customer who calls for bread and butter at an hotel or restaurant from being served with bread and margarine, and paying for it at the rate charged for the higher article. But as the margarine may be assumed to be a perfectly wholesome article of diet, it does not fall within the terms of our reference to make any recommendation upon a practice which is not attended with risk to the public health.

28. 'We wish to state as our opinion that the departmental

machinery for controlling the preparation and conservation of food and drink in this country is not as complete as could be wished. The obvious fact has been referred to by several witnesses, that new methods of preserving, and new preserving agents and colouring matters, will continue to be introduced. We regard it as a matter of concern for the public health that the nature of such substances or processes should be critically examined, and their effects upon the human economy, if possible, ascertained.

'*Recommendations.*—Based upon the foregoing conclusions, we beg to make the following recommendations:

'(*a.*) That the use of formaldehyde or formalin, or preparations thereof, in foods or drinks be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 gr. per pint in liquid food and 1 gr. per pound in solid food. Its presence in all cases to be declared.

'(*b.*) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Act.

'(*c.*) That the only preservative which it shall be lawful to use in cream be boric acid or mixtures of boric acid and borax, and in amount not exceeding 0·25 per cent. expressed as boric acid. The amount of such preservative to be notified by a label upon the vessel.

'(*d.*) That the only preservative permitted to be used in butter and margarine be boric acid or mixtures of boric acid and borax, to be used in proportions not exceeding 0·5 per cent. expressed as boric acid.

'(*e.*) That in the case of all dietetic preparations intended for the use of invalids or infants, chemical preservatives of all kinds be prohibited.

'(*f.*) That the use of copper salts in the so-called greening of preserved foods be prohibited.

'(*g.*) That means be provided, either by the establishment of a separate Court of Reference or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in food, and to prepare schedules of such as may be considered inimical to the public health.'

APPENDIX II

LAW AND PRACTICE IN CERTAIN FOREIGN COUNTRIES AND THE COLONIES AS TO PRESERVATIVES AND COLOURING MATTERS IN FOOD

Austria-Hungary.—No special law obtains. Ministerial decrees are, however, in force prohibiting the use of certain well-known preservatives and colouring matters in foods. Generally at present exceptions to prohibition of preservatives are made only in respect of salt in butter to 5 per cent., and both salt and saltpetre to unlimited extent in meat preservation. But in milk, salicylic acid, borax, boracic acid, and soda are forbidden.

In Austria-Hungary a decree of 1866 forbids in food the use of any colouring matter which contains metals (iron excepted), gamboge, picric acid or aniline. But in 1895 a large number of aniline dyestuffs which do not contain arsenic were permitted to be used for sweetmeats, liquors, &c.; specimens of such colours to be yearly submitted to official examination.

Belgium.—A decree of 1894 prohibits absolutely the use of preservatives in milk.

France.—By the provisions of the law of January 11, 1891, Art. 2, the use in wine of products such as sulphuric, nitric, hydrochloric, salicylic, or boric acids is prohibited.

By an order dated February 7, 1881, the employment of salicylic acid as a preservative was prohibited.

In a circular to the Prefects, dated October 18, 1899, the Minister of the Interior prohibited the sale of foods containing formalin.

Germany.—None of the following substances, nor mixtures containing any of them, are to be used in the preparation of wines or vinous liquors destined for human consumption, nor to be added to such liquors subsequently: soluble aluminous salts (alum, &c.), compounds of barium, boric acid, glycerine, kermes berries, compounds of magnesium, salicylic acid, impure spirits (i.e., containing pure amyl alcohol), impure starch sugar (non-technically pure), compounds of strontium, and colouring tar-stuffs.

NETHERLANDS.—In the Netherlands, by the law of 1889, butter must not contain any foreign ingredients except salt and colouring matter.

SWITZERLAND.—In the Canton of Zurich a law of 1896 prohibits the employment of all preservatives save cooking salt and saltpetre, but borax continues to be largely used.

UNITED STATES.—No maximum limit laid down as to preservatives, but those having no marked toxic character not absolutely prohibited. All packages to bear testimony to amount and name, if any, used.

As to colouring matters, no maximum limit fixed. No colouring matter to be used unless each package bears testimony to name and amount. No absolute prohibition of any colouring matter which has no marked toxic character.

Legislation in the matter of the use of preservatives was passed during the year 1901 in the State of Massachusetts, in virtue of which the quantity and nature of the preservative is to be declared in the case of all articles of food and drink to which an antiseptic substance is added.

Exception is made in the case of table salt, saltpetre, cane-sugar, alcohol, vinegar, spices, the natural product of the smoking process for smoked goods, and where small quantities of suitable preservative substances are dusted on the surface of dried fish and meat.

In the State of Pennsylvania it is a demeanour to manufacture, sell, consign, offer for sale, or have in possession with intent to sell, any article of food or drink which contains formaldehyde, sulphurous acid or sulphites, boric acid or borates, salicylic acid or salicylates, saccharin, dulcin, glucin, B.-naphthol, abrastol, asaprol, fluorides, fluoborates, fluosilicates, or other fluorine compounds, and all other preservatives injurious to health. Common salt, saltpetre, vinegar, and the condimental preservatives such as turmeric, mustard, pepper and other spices are permitted. The penalty for violation of the Act is a fine of not less than 12*l.* nor more than 20*l.*, with costs, or imprisonment not exceeding 60 days, or both.

BRITISH CANADA.—The law does not prevent the use of preservatives and colouring matters in food unless they are injurious to health.

PLATES

PLATE I

FIG. 1. Clump of actinomyces. × 800. After Klein.
2. Nodule due to actinomyces from tongue of cow. × 300. After Klein.
3. Actinomyces, section of nodule. × 120.
4. Actinomyces in pus. × 120.
5. Trichina spiralis in muscle. Longitudinal section. × 5.
6. Trichina spiralis in muscle. Transverse section. × 5.

PLATE I

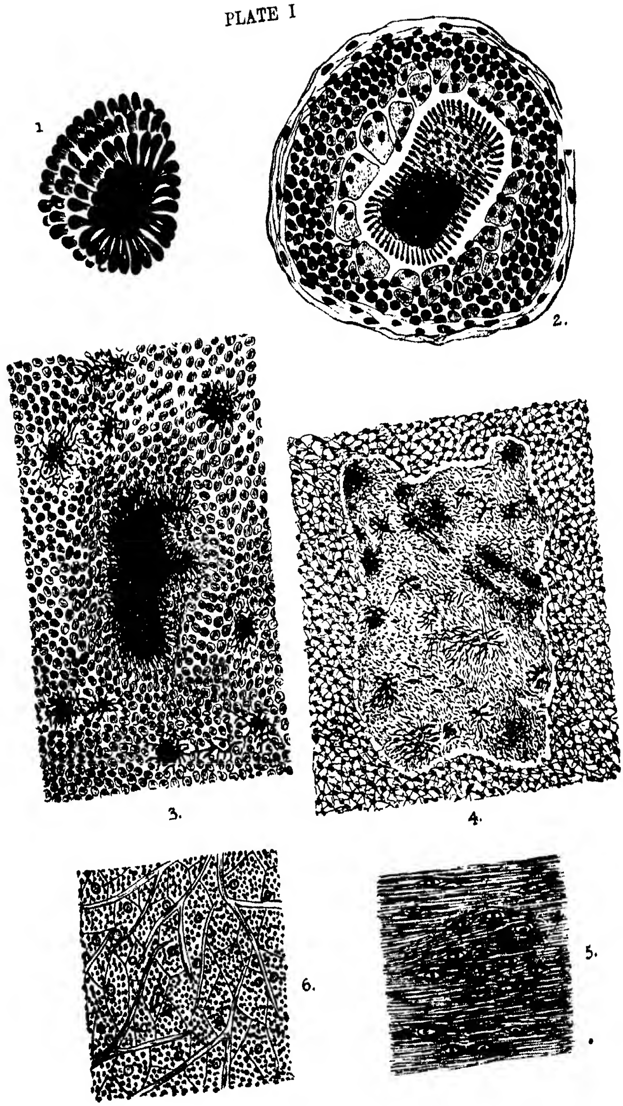


PLATE II

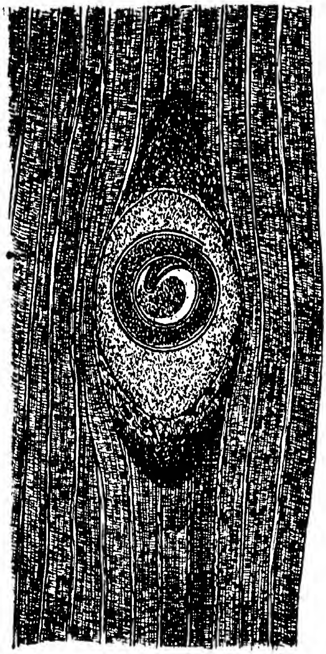
FIG. 1. Trichina spiralis in muscle. Longitudinal section. × 125. Showing the trichina encysted with fat-cells at the poles.

2. Trichina spiralis in muscle. Transverse section. × 125.

3. Trichina spiralis with cyst partially calcified. × 80.

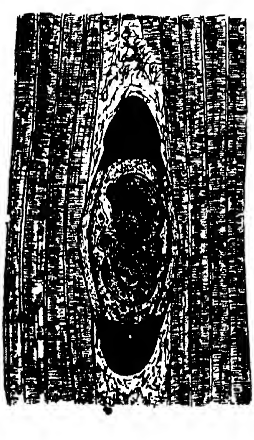
4. Trichina spiralis with cyst completely calcified. × 80.

PLATE II



1.

2.



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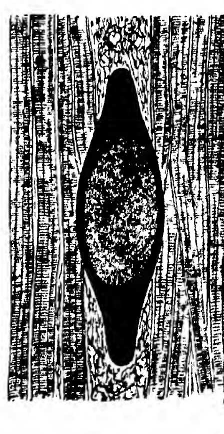


4.

PLATE III

FIG. 1. Tænia mediocanellata, head of. × 35.

2. Cysticercus bovis (beef bladder worm) with scolex extended. After Leuckart. × 4.

3. Cysticercus cellulosæ (hog bladder worm) with scolex included in vesicle. After Leuckart. × 4.

4. Cysticercus cellulosæ with scolex extended. After Leuckart. × 4.

5. Scolex of cysticercus cellulosæ showing hooklets. × 35.

6. Bothriocephalus latus, slightly reduced. After Leuckart.

7. Bothriocephalus latus, one of proglottides, magnified, showing reproductive organs. After Leuckart.

8. Bothriocephalus latus, larvæ of. After Leuckart.

9. Bothriocephalus latus, head or scolex of, showing slit-like sucker, and absence of hooklets. After Leuckart. × 5.

10. Tænia echinococcus. After Leuckart. × 5.

11. Cyst of Echinococcus polymorphus, showing brood capsules (slightly reduced). After Leuckart.

PLATE III

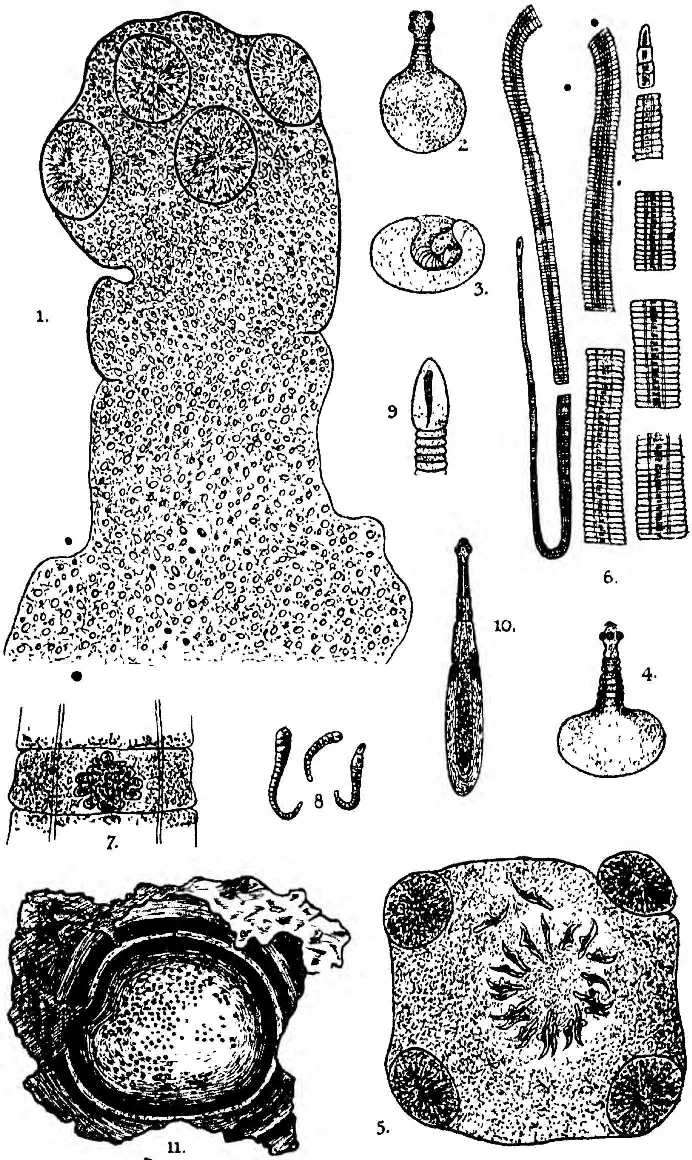


PLATE IV

FIG. 1. Echinococcus polymorphus. Brood capsule with scolices. After Leuckart. × 5.

2. Echinococcus polymorphus, scolex of, with invaginated suckers and hooklets. After Leuckart. × 150.

3. Echinococcus polymorphus, scolex with suckers and hooklets extended. After Leuckart. × 150.

4. Cysts of Echinococcus veterinorum, portion of, from liver of ox, showing scolices. × 35.

5. Cysticercus of hare, head of, showing hooklets and suckers. × 60.

6. Scolex of Echinococcus veterinorum. × 250.

PLATE IV

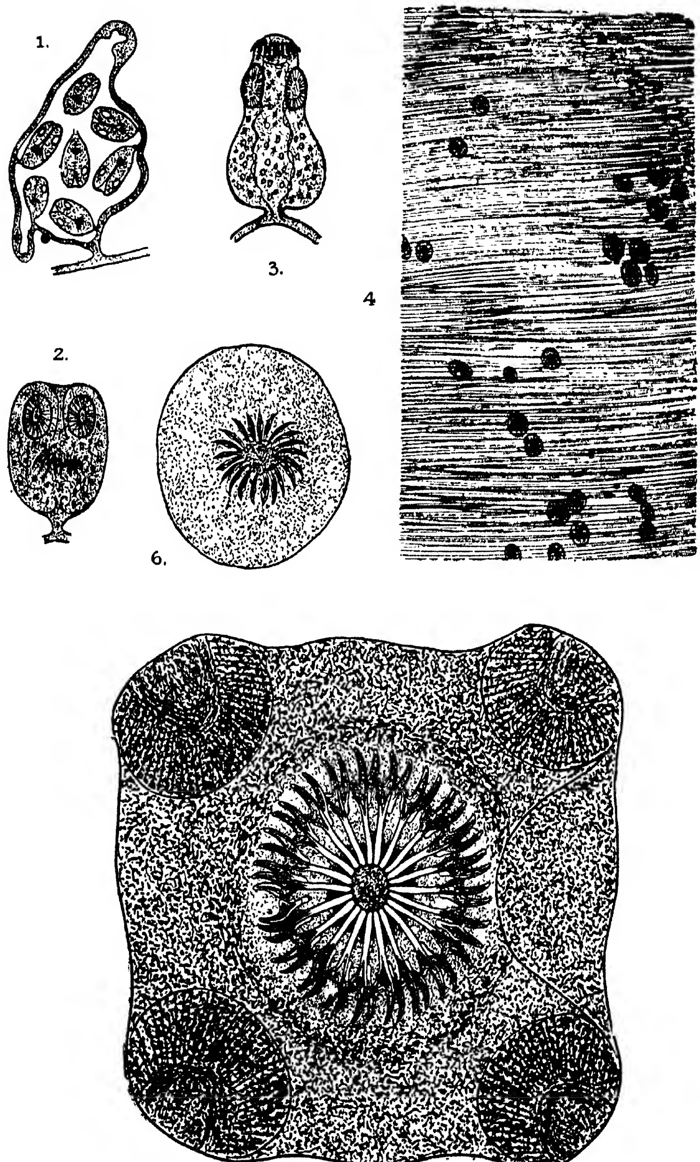


PLATE V

FIG. 1. Distoma hepaticum. Liver fluke. × $1\frac{1}{2}$.

2. Distoma lanceolatum. After Nicholson. × 6.
3. Distoma lanceolatum. × 1.
4. Pentastomum denticulatum, from liver of hare. × 30.
5. Coccidia oviforme. Portion of bile duct of rabbit.
6. Coccidia oviforme. Portion of bile duct of rabbit, sporocysts. × 250.
7. Miescher's sac, from muscle of pig. × 30.
8. Deposit from unclean milk.
   - A. Portion of wing scale of insect. × 250.
   - B. Fragments of hay, straw, &c. × 250.
   - C. Cotton fibre. × 250.
   - D. Fat globules. × 500.
   - E. Oidium lactis. × 250.
   - F. Pus cells (?). × 500.
   - G, H, K. Micrococci and spores of fungi. × 500.
   - L. Bacilli and spirilla. × 500.
   - M. Oidium albicans. After Grawitz. × 250. Introduced for comparison with Oidium lactis.

PLATE V

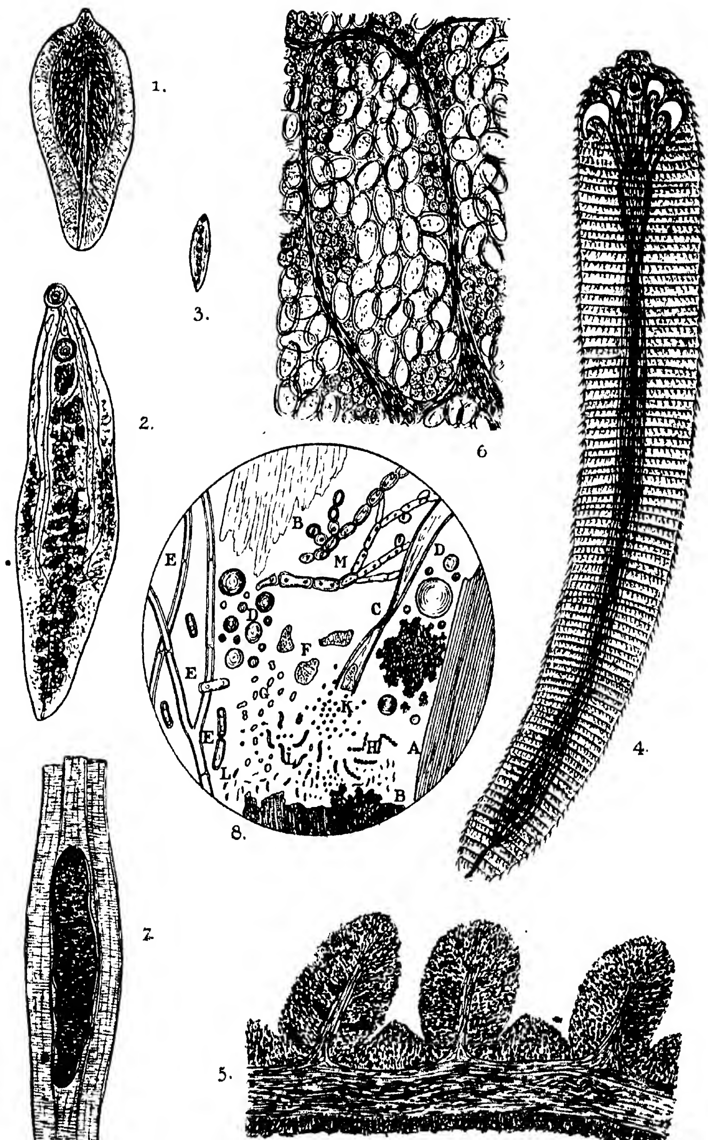


PLATE VI

FIG. 1. Vibrio tritici (red blight of wheat). × 80.

2. Tyroglyphus farinæ (meal mites). × 80.

3. Penicillium glaucum (green mould).

   A. Constricted spores on sterigmata. × 250.

   B. Constricted spores on sterigmata, after boiling thirty minutes in syrup.

   C. Typical head of penicillium. × 75.

4. Aspergillus (eurotium) glaucus (blue mould). × 250.

   A. Hyphæ bearing sexual reproductive organs.

   B. Mature perithecium.

5. Aspergillus (eurotium) glaucus. Thick hyphæ bearing asexual reproductive organs (sterigmata). × 250.

   A. Spore. × 750.

PLATE VI

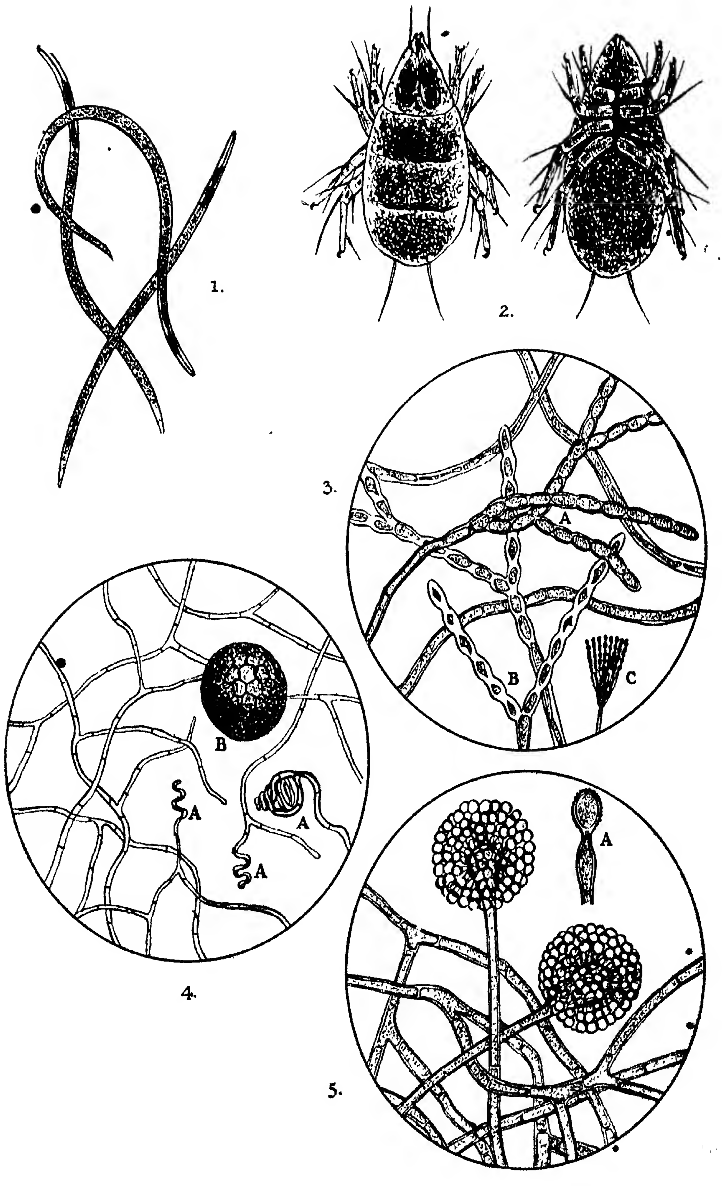


PLATE VII.

FIG. 1. Mucor mucedo (white mould).

A. Mycelia and sporangia. × 15.

B. Mycelia and sporangia. × 150.

C. Hyphæ showing columella and remains of sporangia after spores have been dispersed. × 120.

2. Crushed Darnel seed (Lolium temulentum), diseased.

A. Testa, or seed coat. × 125.

B. Husk. × 125.

C. Awn. × 125.

D. Proteid cells. × 125.

E. Starch granules. × 250.

F. Teleuto-spores of Puccinia graminis. × 300.

G. Conidial spores of ergot. × 300.

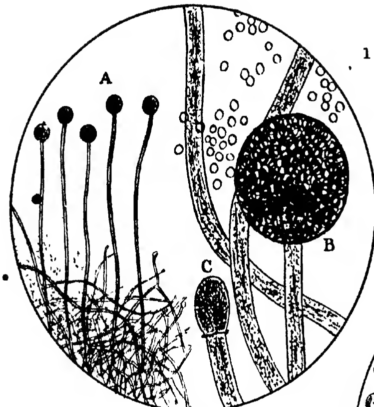
H. One of cells of testa, showing structure of walls. × 500.

3. Spores of Ustilago segetum (smut on wheat grain). × 500.

4. Spores and hyphæ of Uredo fœtida (bunt of corn). × 500.

PLATE VII

1



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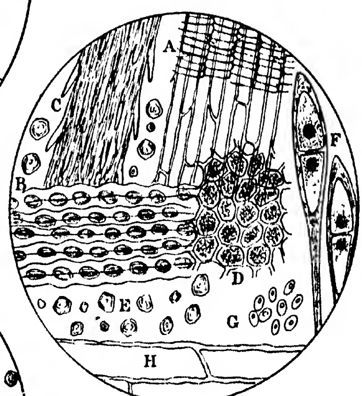

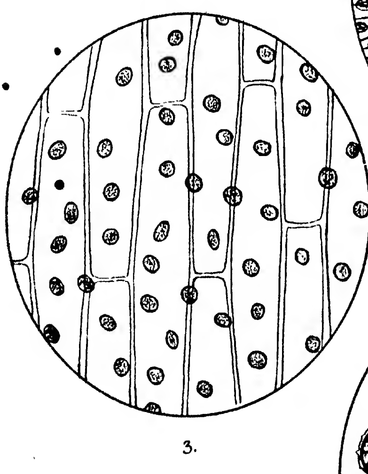

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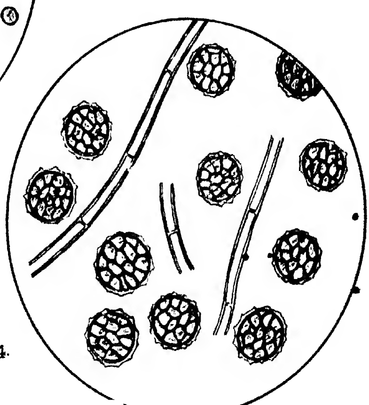


4.

PLATE VIII

FIG. 1. Wheat flour, damaged by exposure to damp. × 300.

A. Starch granules.

B. Mass of gluten.

C. Yeast cells.

D. Fungoid growth, resembling Oidium lactis, but larger.

E. Particles of dust.

The whole swarming with bacteria, chiefly large bacilli.

2. Crushed wheat grain.

A. Testa. × 125.

B. Apical hair of grain. × 125.

C. Starch. × 250.

D. Layer of proteid cells immediately under testa. × 125.

E. One of cells of testa, showing structure of walls. × 250.

3. Maize affected by Ustilago maydis.

A. Disorganized parenchymatous tissue, and spores. × 125.

B. Spore of Ustilago maydis. 600.

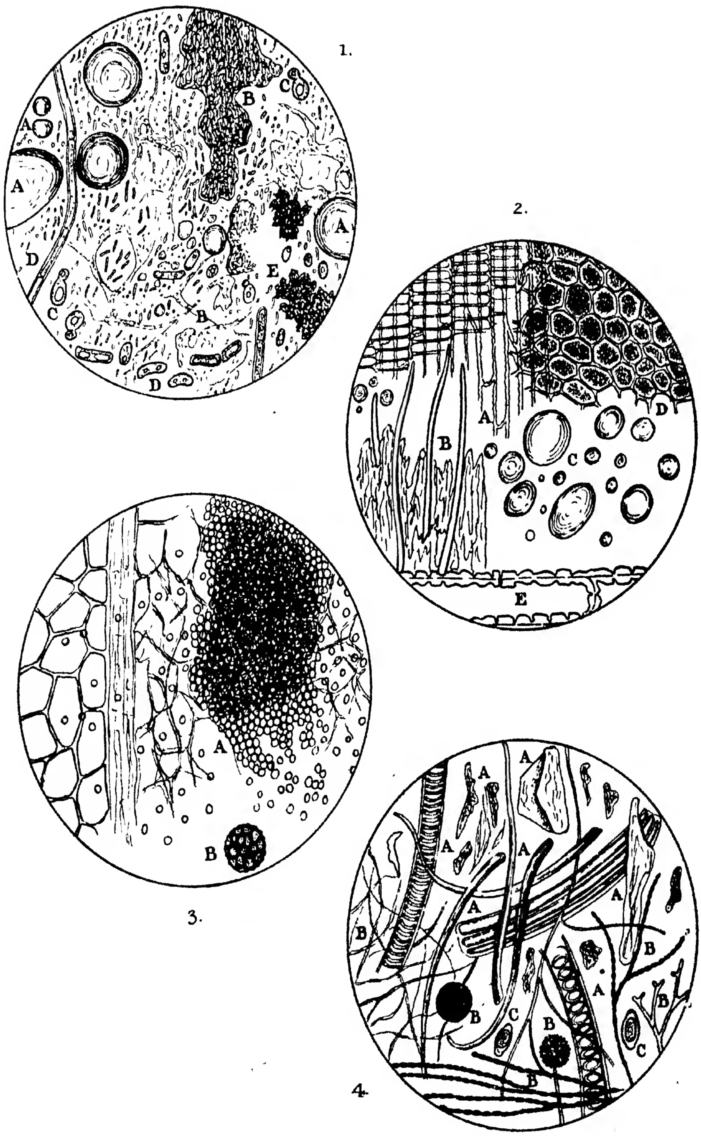
4. Jam made from mouldy fruit.

A. Cells from fruit pulp. × 75.

B. Penicillium, aspergillus, and other moulds showing mycelia and sporangia. × 75.

C. Mould, spores of. × 600.

PLATE VIII



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